Better Crops WITH PLANT FOOD

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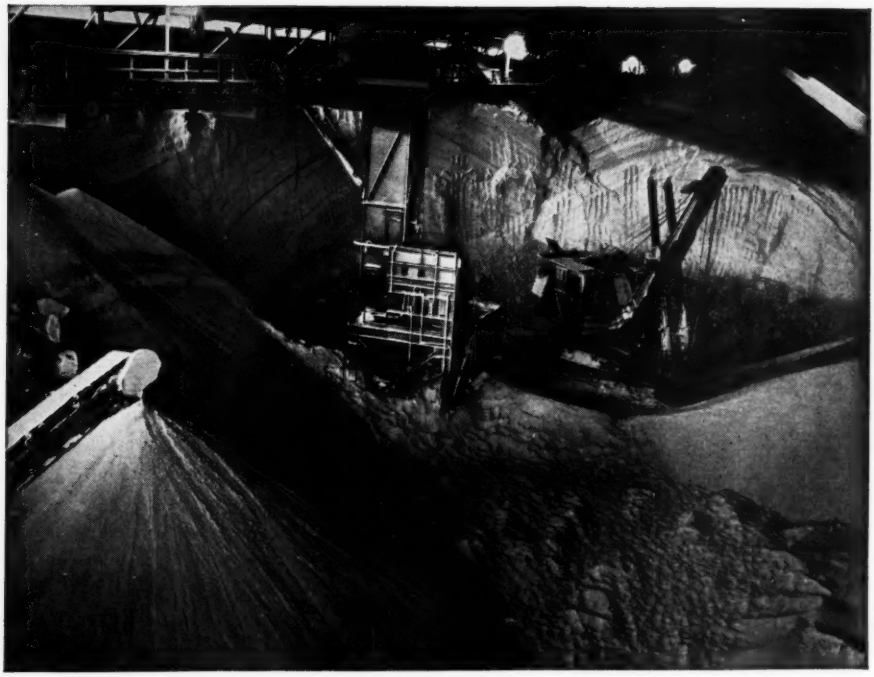

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THE AMERICAN POTASH INSTITUTE

1102 Sixteenth St., N. W. Washington 6, D. C.

Better Crops with PLANT FOOD

The Whole Truth—Not Selected Truth

R. H. STINCHFIELD, *Editor*

Editorial Office: 1102 16th Street, N. W., Washington 6, D. C.

VOLUME XXXVII NO. 10

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VOL. XXXVII WASHINGTON, D. C., DECEMBER 1953 No. 10

Christmastide with . . .

One Plus or Minus

Jeff McDermid

BEING by yourself is all right if you're not actually "beside yourself." And as for being alone, one must beware of becoming lonely. This is especially true as we come to the Christmastide.

During the busy years of ordinary family duties and employment activities, a guy is often left alone, or even sometimes chooses to be alone for sake of variety, to give the family a rest, or for a chance to square up some things with himself. Stranded thus for a short time he lets the dirty dishes stack up and shirks responsibility for all the daily chores which make a house into a home.

Meanwhile as one looks about at neighbors and fellow employees it seldom occurs to a home-keeping gent to consider how very many good people are actually living singly, off by themselves in some small apartment or quiet room. If one ever does think about it at all, it's just to wonder how they got that way and how they pass the time from the closing hour each night or during the two-day week end, when work stops and rest and repose are supposed to take over. How they manage for decent meals is another conjecture.

It's not until you yourself are obliged by fate to join the caravan of "live-aloners" and your own household partner is permanently gone that the stark reality of life in a single cell obtrudes on your daily routine and causes you to inquire into the experiences of other similar "lorn critters."

Maybe you dismiss it by saying that some old maid or cautious bachelor in your circle deserves to face the future

in a hall bedroom. If he or she, you think, had taken the plunge into matrimony in a sensible traditional way several years ago, all this forlorn selfishness could have been transformed into the congeniality that is usually associated with happy families and group living.

Yet somehow that never quite answers your question or resolves your dilemma. For despite their woeful deprivation from the joys of plural living, such time-tried and expert single-livers have a little edge on one who is suddenly thrust from communion with a lifelong associate and cast up rudely on the rocky shoals of advancing age. It matters little who that associate was —wife, mother, sister, or chum. Something vital has been lost and old habits broken down. It is up to him to try and pick up such synthetic comfort as he may find among the littered wreckage of an old association.

THESE apparently well-seasoned single ones whose lives have neither shared the happiness nor felt the lash of sorrow or defeat so inherent in family relations are good people to seek. They possess certain assurances and formulas that a poor plural-liver has never had much chance to depend upon.

One of them has a roomful of pet birds to coax into playfulness and song. Another owns a couple of cats in a section where animal companions are not taboo. Here is a person with musical or art hobbies and accomplishments, and another is devoted to fraternal rituals and duties. Others cling to the church and its wholesome outlets for energy and forgetfulness of self.

But too many of them have no talents, no goals, few hopes, little faith or fervor, no anchor, nor any children to become devoted to as time goes inexorably onward. The fortunate ones who are blessed with nephews, nieces, or young cousins, or who find some needy youngsters to aid, always seem to come as close to a perfect state of lonely bliss as this world ever permits. They are able to forget themselves awhile as they trim dolls, carve toys, or save a bit from their wages as a means to brighten a juvenile mind and spirit at Christmas time.

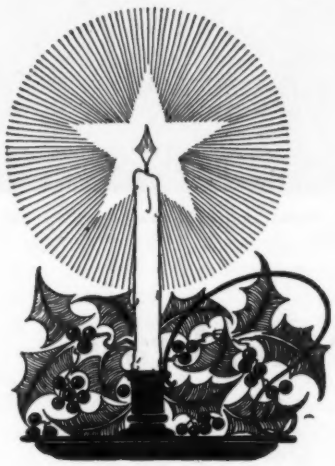
Some folks naturally find it easier to live with themselves than others do. Often this talent for privacy or insurance against bitter loneliness traces clear back to their youth. I have known boys and girls who lived in a realm of imagery and spent hours amusing themselves out of trifles—like quiet woodland bowers or fishing trips, or books read on some overlooking hill where the vistas below spread themselves (as life itself so often does) in sunshine and cloud shadows, with the fog rising suddenly in the distance to reveal the sparkling river rolling onward to the sea.

TO such accustomed ones the passing of the lengthy hours holds less irksome boredom as they grow older. For they began their youth with a serenity of spirit which need not always claim the joy of human companionship for its inward satisfaction.

Take such an unmarried one who in subsequent years continues his solitary way in the busy world—he never loses part of that self-reliance from having to depend upon the life and the love of another. But for the other type—the gregarious family one—it is harder for him to return to self-renewal and content along the pattern he used to follow in the era of adolescent day-dreaming in the bright Elysian fields of make-believe. He wishes he might. He'd like to realize again the detachment of boyhood and the freedom from anybody's ideas or ideals—the dawn time of life when one plans vaguely and hopes prayerfully for personal success. The trouble is that the young dreamer never knows that sweeter and better things are in store for him than treasure at the rainbow's end. He never senses that there are heartstrings mightier than pursestrings.

Those "first person singulars" have become experts at looking after themselves. Yet the one who has given but

a passing thought or only a word of commendatory appreciation for a myriad of personal services in the household, seldom escapes a sort of panic when he inherits all those unfamiliar details himself. He recalls how his bride assumed all and sundry cares with calm resourcefulness. He cannot recall when she was much upset by strange tasks—even when those first biscuits were tough and tasted bitter. And why should he recoil against



routine home chores as long as he has no kid rompers to sew or socks to darn?

He thinks perhaps he should wash the windows on Saturday, to keep up appearances and let in some sunlight for a change. He uses soap and hot water and does a poor job of rinsing and drying. There's nobody inside to tap loudly on the panes and point to streaks of cloudy blurs he missed. There's nobody to grumble at either. He then tries to dust and re-hang the curtains, but they sag and look unevenly limp and dreary. He thinks that all he requires for cleaning the big woolen rugs is a vacuum sweeper run every week over all surfaces and edges. But one day he lifts the heavy carpeting to see twisted lint and many specks of dust, and here and there bits of white clinging to the textile's undersides. Maybe those are the larvae of that squatty, bluish bug that just wriggled out of the fringe. On his knees now, he examines the fabric and finds a few small holes the size a tack would make. Hastily, he rushes to the drugstore and gets some bottles of "larvex" liquid to squirt madly on the rugs.

He sloshes some of it on his old tuxedo hanging there in the dark closet in memory of bridge-club days. It has acquired a gaping hole in the shoulder half as big as a dime. Perhaps he won't use the old tux again because social ex-pluralites do not usually get asked to formal parties—but he wants it to sell fairly well some day at the handy "not new" clothing exchange.

He avoids conversing about menus with those smug old-timers at single living who boast that they have much in common with President Eisenhower when it comes to cooking, stewing and serving steaks, soups and salads. The type of lone-dwellers he likes and has much fun talking with are those "breakfast only" guys who refuse to learn any new or tedious tricks in the kitchen.

"All I ever do for myself in the food line is in the morning, when I fry some eggs and bacon and burn me up a little toast and pour boiling water into a cup with coffee powder and condensed milk," your chum proclaims. "I buy the rest of my eatments ready for business," he states.

"Yes, that's me too," you reply. "By the time I get home nights and put all the stuff on the fire and set the table, I'm too confounded tired and mad at myself to eat. So it's me to the lunch counter or the neighborhood restaurant, much as I wish for other days. Breakfast is all I can handle myself, and sometimes I even skip that."

Sometimes a desperate deprived homemaker will follow some poor advice in his anxiety to make life fuller. I had a friend who was told to get hold of a new bulletin for the single householder. It was written in the home economics division of the Department

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Fig. 1. Something is missing between the urine spots. Urine contains about equal amounts of nitrogen and potash.

Nebuchadnezzar Ate Grass

By Firman E. Bear

Soils Department, Rutgers University, New Brunswick, New Jersey

IN the Book of Daniel we read: "The same hour was the thing (prophecy) fulfilled upon Nebuchadnezzar. And he was driven from men and did eat grass as oxen, and his body was wet with the dew of heaven, till his hairs were grown like eagles' feathers and his nails like birds' claws."

In Nebuchadnezzar's day, grass probably meant everything that grew naturally on grazed land, including many varieties of weeds and herbs as well as grasses and legumes. Weeds and herbs are not to be taken lightly. Many of them have value as sources of compounds that have corrective, stimulatory, and supplementary food values. They tend to be high in minerals, particularly in trace elements. The modern tendency to eliminate all weeds and wild vegetation in favor of a limited mixture of bromegrass and ladino clover, or similar grass-legume mixtures, leaves much to be desired. It is interesting to see how closely cows graze on old bluegrass pasture, with its great variety of miscellaneous wild grasses, legumes, and weeds, when what appears to be much better grazing is close at hand. And virtually every cow will go out of her way to eat the shrubs and weeds along fence rows and to reach through the fences themselves in search of something that is missing in the forage grown especially for her. One sometimes finds cattle eating the soil itself in some special location along a fencerow.

Kentucky bluegrass is an especially interesting plant in this connection. When grown on identical soil with other grasses and legumes, it stood at the top of the list in content of iron, zinc, copper, and cobalt, all important elements in animal nutrition. There may be very good reason for the preference cows appear to have for good bluegrass pasture.

Nebuchadnezzar had been badly pampered, living on fancy foods designed especially to tempt his palate. It was not until he got away from the palace and out in the open field, where he had access to the products of Nature undefiled, well-spiced with dust and dung, that he recovered his strength of body and peace of mind.

But we have long since passed the point where we can afford to let Nature take her own course. Even though the natural produce may have excellent quality, it lacks quantity. And it leaves much to be desired in the way of month-to-month distribution of both quantity and quality. So our primary motive becomes one of directing Nature to our own ends. Since man is a product of Nature and has a brain, that brain should be made to function in behalf of the livestock that are under his care.

The yearly forage-producing potentiality of one acre of good land in northeastern United States is of the order of five tons dry matter containing about 15 per cent protein. If it produces less than this quantity of good feed, the soil is too wet or too droughty, it has not been limed and fertilized, or the forage crops have been poorly chosen or overgrazed.

To obtain any such quantity of high quality feed from one acre of an old permanent pasture requires that something quite drastic be done. An unlimed and unfertilized pasture seldom produces more than one ton dry weight of forage a season. It needs help if it is to yield more than this. A lot can be accomplished merely by applying pulverized limestone and complete fertilizer to the permanent grass sod, coupling this with controlled, rotational grazing. Yet, even so, a well-limed and well-fertilized bluegrass-white clover permanent pasture seldom yields more than two tons dry weight of grass and clover an acre, which is only 40 per cent of the forage-producing capacity of good soil. If the lay of the land and the nature of the soil permit, there is nothing that quite takes the place of working the soil up thoroughly, mixing limestone and fertilizer deeply into it, and seeding the field down to a good, improved mixture of grasses and legumes. It is only on this basis that the 5-ton an acre potentiality in forage production can be realized, and this only for hay or silage. Pasture potentialities are of the order of 3½ tons dry matter.

Problems Involved

But reseeding rolling land has long presented a very serious problem. To plow the land, prepare it, apply the necessary soil amendments, sow the seed, and get a ground cover quickly enough to avoid losing a large part of the topsoil to the creek that lies at the bottom of the slope is no simple matter. An answer to this problem has been found in the use of chemicals to kill the old sod. The dead sod is then left largely as a mulch on top the soil, after the relatively simple task of discing the land or using a tool-bar cultivator in preparation for seeding has been done. The preferred method of seeding is in bands, with fertilizer beneath, and use of a cultipacker afterward.

This is the first step toward quantity and quality production of forage, whether this forage is to be used for soiling, grazing, silage, or hay. Since such reseeding is not likely to be repeated oftener than once in 10 years, it is important that the whole program be thought through and applied rightly. Enough limestone should be applied to raise the pH of the soil to 6.5 to as great a depth as it can be worked in. In no case should this application be less than two tons an acre on the heavier rolling

land.

More fertilizer should be applied than one thinks he can afford. A reasonable application is 500 pounds of an 8-16-16 fertilizer an acre, worked in as deeply as possible with a disc. Twice that quantity of fertilizer will pay good dividends where the extra forage can be used to advantage. Some of this fertilizer should be placed directly beneath the seed as an aid in getting the young plants off to a quick start. Some of it should be worked down several inches deep in the soil. This is much better than plowing it under.

The seeding mixture merits a great deal more study than it has had. The normal procedure is to sow timothy, brome, or orchard grass and ladino clover. We need a greater variety of plants, including several species other than grasses and legumes that vary greatly in chemical make-up and in the nature, distribution, and depth of their root systems. Fortunately, Nature takes a hand in this and usually puts in quite a few extra varieties of plants of her own choosing. We should be able to do a better job of choosing than Nature can.

Liberal liming, fertilizing, and seeding will get the crop under way and produce a good yield the first year, with the possibility of some improvement the second year. But it is just as important to apply fertilizer regularly to a forage crop as to grain, vegetable, potato, and tobacco crops. The only possible assistance legumes can render to mixed forage is that of taking care of their own nitrogen needs, and possibly spilling over a little to help the grasses. But both the grasses and the legumes must be fed. The grasses need nitrogen, in addition to the small quantity that may be supplied by the associated legume, and they are very heavy consumers of potash. Generally speaking, grasses contain about one per cent more potash than the clovers growing alongside them. It is for this reason that, unless extra potash is applied, the clovers tend to disappear from grass-clover mixtures. One should think in terms of not less than 100 pounds of potash an acre annually for mixed grass-legume hay crops. Less than this amount of potash may suffice for grazed lands.

There is a fundamental difference between the fertility problems on land that is grazed and land that is used for production of hay and silage. In our

Fig. 2. High-producing cows go with high-producing pastures.

tests, a 1,300-pound Holstein cow produced 21 tons of manure a year containing about 200 pounds nitrogen, 63 pounds phosphoric acid, and 168 pounds potash. Of this, 75 per cent was dung and 25 per cent urine. Nearly 80 per cent of the nitrogen, phosphoric acid, and potash that went into the mouth of cow was returned in the form of dung and urine.

While a cow is on pasture during the summer months, possibly half of her manure is dropped in the field. If we assume that the pasture is capable of supporting the equivalent of one cow an acre for a 6-month period, the manure of that cow would return over 50 pounds N, 15 pounds P_2O_5, and 40 pounds K_2O to the grazed acre.

This indicates the need to consider two points. One is that the heavier the dosage of fertilizer to grazed land the greater the return of nutrients by way of manure to the land for reuse by succeeding growths. The other is that need for fertilizer, particularly potash, is much greater on land that is to be used for hay and silage crops than it is on improved grazed land.

A great deal of the grass on pasture fields is wasted because animals tramp a lot of it down, and still more is spoiled by dung and urine. That which is distasteful in the green state can be made palatable by mowing, thus giving the animals a chance to eat it as hay to supplement the grass while they are grazing. Widespread interest has recently been developed in the soiling system in which the crop is harvested green and brought to the cow. In proportion as this can be done, there is greater hope of realizing the 10,000 pounds dry weight of produce an acre annually, which was set as the goal.

Trace elements now constitute one of our major problems in legume production. So many cases of boron, magnesium, manganese, and molybdenum deficiencies have developed that it has become necessary to be constantly on guard against a lack of one or more of these elements. Boron deficiencies are widespread and, in such areas, call for about 25 pounds borax an acre annually. Magnesium deficiencies are common in coastal plain areas and in those where high-calcium limestone has long been used. The remedy here is to switch to a high-magnesium stone or to add magnesium to the fertilizer. Overliming can lead to difficulties, partic-

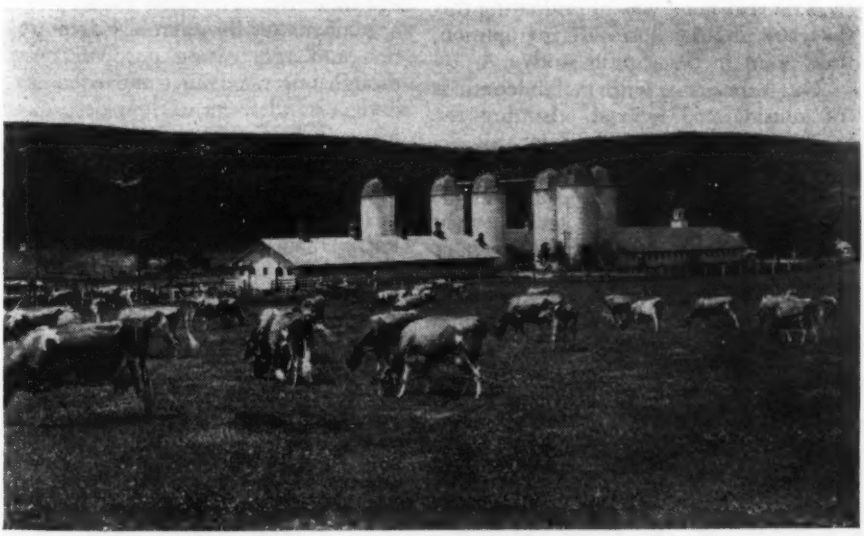

Fig. 3. Plenty of potash and close rotational grazing keep clover in the sward.

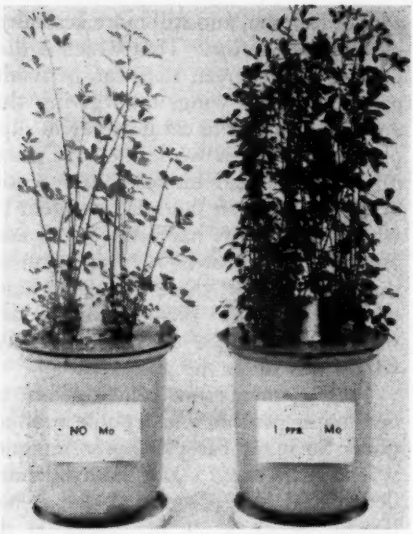

Fig. 4. Trace elements—in this case molybdenum—are especially important for legume crops.

ularly with manganese, reducing availability of this element to the point where growth of legumes is limited. It has been suggested that low manganese values tend to increase the tendency toward difficulty with contagious abortion. In a study of this possibility we found great variation in the manganese content of mixed hays, but there was no very good way of evaluating this in terms of Brucellosis. In my opinion, this point merits careful study.

Our experience with molybdenum is of considerable interest. Liming the soil increases the availability of this element and this may be one reason why lime is so essential to some crops. Molybdenum deficiency tends to be most serious on acid soils and can be remedied in part by liming. But in a series of tests we obtained significant yield increases in four of six alfalfa fields from applications of one pound sodium molybdate an acre. In one case this increase amounted to nearly 28 per cent.

So far as the cow is concerned, it seems probable that any deficiencies of such elements as cobalt, iodine, and fluorine can best be remedied by way of the feed, salt, or water. Such deficiencies are known to exist and must be carefully watched for in order to avoid low milk production and lack of capacity to reproduce.

We have now arrived at the point where forage crop production is looked upon as permitting as large an investment in the elements of soil fertility as any other crop. This is on the assumption, of course, that we are dealing with cows that produce 10,000 pounds of milk annually. It's a waste of time and money to go to the trouble of growing good forage to feed to a poor cow.

The place of grasslands in the general crop-rotation program is so well recognized that it does not seem necessary to give it any very extended attention in this discussion. Grasses and clovers serve fundamentally different purposes in such rotations. Grass roots sew the soil to the earth and stop erosion. They permeate the soil in mass formation, dry it out, and thus develop aggregates. They also make lines of weakness, so that when a lump of soil is struck by a tillage implement it falls to pieces.

Legumes, particularly alfalfa, sweet clover, and sericea, are especially useful in opening up deep aeration and drainage channels. They provide deep-down organic matter for microbial decomposition and aggregating purposes. Even though one may not want to try for a perfect stand of one of these deep-rooted legumes, he should include seed of it in his seeding mixture.

The nitrogen-accumulating powers of legumes are of much less importance today than they were 50 years ago. Legumes have great value as high-yield, high-mineral, and high-protein feeds. But in proportion as fertility levels are raised to meet the needs of 100-bushel corn crops, 50-bushel wheat crops, 500-bushel potato crops, and 20-ton tomato crops, legumes take more nitrogen from the soil and less from the air. They have a remarkably good effect when plowed under because their nitrogen

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White Birch Helps Restore Potash-deficient Forest Soils[1]

By Laurence C. Walker

Research Forester, Southern Forest Experiment Station, Brewton, Ala.

DEEP sandy soils occur rather extensively in the Adirondack Mountains of New York State. These level "sand plains," as they are locally called, were formed from glacial river deposits as lake terraces during the late Pleistocene ice age. As the glacier receded and the lakes were drained by nature, expanses of easily tilled soil were uncovered. Virgin spruce, pine, and hemlock forests followed in the course of history. Then, because of the favorable topography of the flat lands, farmers broke new ground early in the nineteenth century. One hundred years of intensive agriculture followed. During that time little, if any, fertilizer was applied or soil-improving crops used; and the farm lands, depleted of their natural fertility, were finally abandoned. "The raising of field crops or animals was no longer profitable."

Then, around 1930, foresters decided to put these lands back to work. Pines, spruces, and other conifers were planted on the old fields; and once again the prehistoric lake terraces were supporting trees. But after a few years it became evident that these plantations weren't growing satisfactorily. Symptoms of a nutrient deficiency appeared.

Professors S. O. Heiberg and D. P. White of the College of Forestry at Syracuse, N. Y., attributed these malformations—slow growth and small chlorotic needles which drop off prematurely—to a deficiency of potash in the soil. Subsequently, the symptoms of low potassium availability were noted in native white pines of the region. Dr. E. L. Stone of Cornell has also found this potassium deficiency to accompany shortages of magnesium in sandy soils.

One observation is described here to demonstrate the ability of white birch (*Betula papyrifera*) to restore available potassium to the surface soil. Because of this soil-enriching influence, native white pines (*Pinus strobus*) appear healthy and normal.

In the Charles Lathrop Pack Demonstration Forest, near Warrensburg in the eastern Adirondacks, vigorous white birch trees about 40 feet high occur rather sparsely in an old field. Under these trees are many white pine seedlings and saplings. These pines thrive under the crowns and on all sides of the birches, but only to the crown edge. They manifest none of the characteristics of potassium deficiency. (See cover illustration.) However, isolated white pines scattered throughout the same field but not growing under birch crowns exhibit symptoms of potash malnutrition.

Chemical analyses of the soil showed the amount of exchangeable potassium and acid-soluble phosphorus to be much greater in the plow horizon under the birch-pine groups than in the open. Total nitrogen content is just slightly higher under the leaf canopies (Figure 1). The pH of soil in the plow zone is slightly higher

[1] From an incidental study to a thesis submitted to the faculty of the State University of New York, College of Forestry, for the Ph.D. degree. Acknowledgment is made to Professors D. P. White and S. O. Heiberg for helpful counsel.

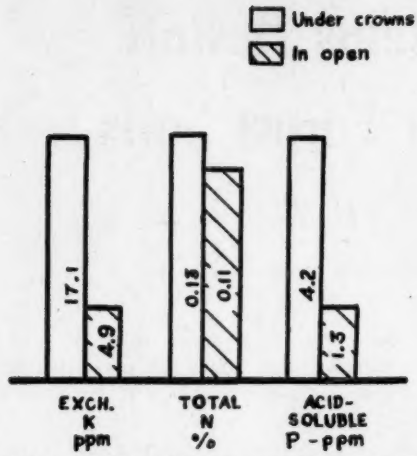

Fig. 1. Potassium, nitrogen, and phosphorus in the plow horizon of soils under white birch and in openings.

under the canopy: 5.3 in contrast to 5.1. In both sites, pH increases with depth to 6.0 in the lower B horizon.

Below the plow horizon, the soils do not seem to differ appreciably. Samples were taken at several depths in soil profiles and from these it was learned that, both in the open and under birches, a rapid decrease in exchangeable potassium occurs with increase in depth. Only traces of exchangeable potassium are present in the upper B horizon and this concentration is relatively constant to a depth of four feet. This emphasizes the importance of the surface soil to the nutrition of plants—even forest trees which often have deep root systems.

The amount of potassium in leaves of three white birches and in needles of three white pines growing under the birches was determined. For comparison, white pines growing in the open were also sampled for analysis. The ameliorating effect of white birch on white pine nutrition, judging from the foliar analyses, is apparent (Table I). The birch has the ability to "forage" for potash in lower horizons and return this nutrient to the surface soil through decomposition of fallen leaves. The element then becomes available to understory pines. As might be expected, these pines have about twice as much foliar potassium as those grown in the open. All open-grown white pine needles sampled were well below the critical potassium limit (0.34%) for this species, determined by Professors Heiberg and White.

One important factor remains unknown! What was the condition of the site under the birches prior to their germination? Did the birches, for instance, come in on brush or ash piles?

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TABLE I.—LEAF AND SOIL ANALYSES FOR POTASSIUM

Sample Pair	Potassium in foliage [1]			Exchangeable potassium	
	White pine		White birch	Under birch crowns	In open
	Under birch crowns	In open			
No.	*Per cent*	*Per cent*	*Per cent*	*ppm*	*ppm*
1	0.55	0.28	0.85	18.5	6.2
2	.48	.28	.58	14.6	4.7
3	.43	.26	.63	18.2	3.8
Average	0.49	0.27	0.69	17.1	4.9

[1] Dry weight basis. August foliage, 1952.

Fig. 1. About two inches of soil were removed from this plowed field in South Carolina during one rain, mainly as a result of raindrop splash. The stone-capped pedestals show that the force causing the erosion was applied from above, as by falling raindrops, and not from the side, as by flowing surface water. The dead plant roots in the foreground protected the soil immediately beneath them while that between and to the sides was splashed away. Little erosion took place in the background where the surface of the ground was protected by plant cover.

Continuous Plant Cover the Key to Soil and Water Conservation

By J. H. Stallings

Research Specialist, Soil Conservation Service, USDA, Washington, D. C.

NATURE performs her marvelous feat of building soil by means of "holding" and "developing" actions. These actions are performed simultaneously by the countless thousands of types and species of plants inhabiting the earth. The first step in the soil-building process is the "holding" action. For this purpose Nature has developed plants suitable for almost every possible combination of soil and climatic conditions.

Moss and lichens often start the "holding" action. They form a protective covering over the rock surface that catches and holds dust. This cover also holds the soil in place as it develops from the surface downward. As soon as the rocky surface has changed sufficiently to support higher forms of plant life, the mosses and lichens are gradually replaced by the next higher plant form in the ecological scale. Further soil improvements in turn are followed by the invasion of still higher forms of plant life until the climax species is reached. At all times, however, the ground surface is protected by

a blanket of plant growth best adapted to the existing environmental conditions.

The second or "developing" step in the soil-building process consists of changing the rock into soil. This, too, is a slow process that requires centuries and involves many changes of plant cover before the climax phase of vegetation is reached. If at any time this plant cover is reduced or removed so that it becomes inadequate to protect the surface, the soil begins to erode and deteriorate. Once this process sets in, the succession of plant life which was active in building the soil is thrown into reverse. As the soil environment becomes less favorable, the lower forms of plant life follow in succession.

This "holding" action was not known to exist until Nature's balance between soil-building and soil-destroying forces was upset by removal of the native plant cover. Even today we do not fully understand or appreciate the nature, extent, and significance of the tremendous forces set in motion by this act. Removing the native plant cover exposed the bare soil to the full force of wind and water. The erosive action of these agents stopped the soil-building process and threw the whole procedure into reverse. Even now, few people realize that this "holding" action is essential for soil and water conservation and, in turn, soil improvement.

The part played by wind in the soil erosion process and methods of its control were presented in other papers (23, 26).[1] Most of the force of falling raindrops is expended as the rain beats against the ground surface. Here, then, is where the resistance is needed to reduce or prevent erosion damage. The major role of cover is to provide resistance to the vertical force of falling raindrops rather than to the horizontal force of overland flow (4, 10, 15).

The most productive portion of the soil is at the surface. As plant life becomes established on the rock surface, organic residues accumulate on top of the ground. Their soluble portions are leached into the ground by rain or snow melt. At first the thin layer of soil at the ground surface absorbs these substances (particularly the soluble organic portions which produce humus) and become dark in color. As further plant residues accumulate on the ground surface, the soil layer becomes thicker and the humus penetrates deeper. But humus accumulates faster at the surface than at lower depths in the soil.

Raindrop Splash Major Factor

Water erosion has generally been thought of solely as the removal of soil by flowing surface water. However, we know now that raindrop impact is the main cause of erosion on cultivated land and without it there would be little erosion (Fig. 1). The amount of damage caused by falling raindrops is proportional to the kinetic energy of the drop. It has been estimated that the kinetic energy of falling raindrops ranges from 1,000 to 100,000 times the work capacity of surface runoff (9, 15).

The erosion process requires energy to detach and carry soil from its original site. The force generated by surface flow is determined by its concentration and speed of movement downhill. Flowing water gains energy by gaining mass as it concentrates at the foot of a slope, or by gaining velocity as it flows down a steep slope. Due to the nature of its source of energy, surface water does not flow evenly over the surface of a field and, therefore, could not cause so-called sheet erosion—which accounts for most of the soil loss from cultivated land.

Raindrop impact, however, is distributed uniformly over the entire surface of a slope. Moreover, it is effective only when the bare soil surface is exposed to the beating action of raindrops. Raindrops detach soil particles and feed them into surface flow, which moves downhill. This combined flow and impact action accounts for 95 to 100 per

[1] Numbers in parenthesis refer to literature cited.

cent of the sediment removed from fields (15).

Plant Cover Intercepts Raindrops

Under field conditions, plant cover controls splash erosion (Fig. 2). The effectiveness of plant cover in preventing soil splash depends upon the amount present when the rain falls. Both the density of cover (to act as a shield) and the weight or bulk of the cover (to absorb the energy of the raindrops) are important in protecting the soil.

Effectiveness of cover is proportional to the amount present. Weight (in pounds per acre) and coverage (per cent of ground surface covered) are practical measurements of about equal value (17). However, the closest indication of effectiveness is obtained when weight is multiplied by coverage to give an index of "effectiveness weight."

The growth forms of different crops influence their effectiveness in controlling splash erosion. Close-growing crops of medium height, such as oats, wheat, and vetch, have almost identical values for the same weight of cover. Tall-growing crops, such as sweetclover and cotton, provide less protection than close-growing crops for the same weight of cover in amounts above 1,000 pounds per acre (17). This, no doubt, is due to the greater bulk and weight of material present in taller crops for a given amount of surface coverage.

The reason tall, coarse crops do not provide as much protection as close-growing crops is because of their more open canopy and the action of intercepted raindrops falling from their foliage.

For 90 per cent effectiveness, approximately 2,500 pounds per acre of close-growing crops or 4,000 pounds of tall, coarse crops are required (17). Below this point, effectiveness declines rapidly as the amount of cover is reduced and the difference between growth forms becomes less important. The midpoints appear at about 85 per cent effectiveness, which requires approximately 2,000 pounds of close-growing crops or about 3,000 pounds per acre of tall, coarse crops. At 1,000 pounds per acre there is no significant difference in the kinds of crops; both are 60 per cent effective.

Fig. 2. Plant cover intercepts falling raindrops, absorbs their kinetic energy, and eliminates their damaging impact action on the ground surface.

The inclusion of a so-called "cover crop" or "soil-depleting" crop in a rotation grown on a certain field does not of itself mean that the field is or is not adequately protected from severe rainstorms. At some period in the life of most crops a maximum rate of erosion is possible, due to inadequate cover whether they are classified as soil-improving or soil-depleting. At other periods, the danger from erosion may be nil even with some so-called soil-depleting crops because they produce a greater bulk of cover at some seasons than many crops grown especially for erosion control.

Plant cover has a controlling influence on splash erosion. When there is sufficient canopy to intercept all the drops and absorb most or all of the energy of the rain before it reaches the soil, even the most easily detached soil is not disturbed. Splash decreases as the amount of cover increases, until virtually complete control is provided.

Fig. 3. Cotton plants in this field did not furnish enough cover for adequate protection of the soil against the impact of falling raindrops. Land planted continuously to cotton in Oklahoma lost the equivalent of all the crop residues left on the ground and 1,860 pounds per acre annually of the soil's original supply of organic matter over a 10-year period. It also lost an average of 18.9 tons of soil per acre annually by erosion.

Soil-Depleting and Soil-Improving Crops

Corn, cotton, peanuts, and the other so-called soil-depleting crops provide inadequate plant cover during the critical summer period of erosion-producing rains (Fig. 3). On the other hand, soil-improving crops, once established, provide plant cover throughout their entire growth period. This lack of adequate plant cover and its protective influence on the soil on the part of the so-called soil-depleting crops, then, is the major difference between soil-depleting and soil-improving crops. In soil-improving crop systems one or more legumes are usually included which add some nitrogen to the soil. The main advantage of soil-improving crops is more continuous and denser cover.

This was illustrated by results from the SCS project at Clarinda, Iowa, where the addition of 180 pounds of nitrogen per acre in 1952 to plots that had grown corn continuously for the past 20 years eliminated the trouble which caused low yields. Since 1932, corn has been grown continuously on one series of plots and in a 3-year rotation of corn, oats, and meadow on another. The corn in each series received the same fertilizer treatment until 1952. The fertilizer treatment was the same again in 1952 except for the fact that the continuous corn plots received 180 pounds of nitrogen per acre. The yields in 1952 were 103.0 bushels per acre on the continuous corn plots and 98.4 on the rotation plots (18).

The average annual yields of corn in bushels per acre by 5-year periods and for 1952 for both series of plots are given in Table I.

Beginning with the second 5-year period the yield on the continuous corn plots declined from 32.5 bushels per acre to 17.8 for the fourth 5-year period. During this time the yield on the rotation plots increased from 57.0 bushels per acre for the second 5-year period to 83.9 for the fourth. The difference between the yields of these two series of plots also became greater with time. It was 1.9 bushels per acre for the first

TABLE I.—THE AVERAGE ANNUAL YIELD OF CORN IN BUSHELS PER ACRE BY 5-YEAR PERIODS AND FOR 1952 FOR CORN GROWN CONTINUOUSLY, AND IN A 3-YEAR ROTATION DURING THE PERIOD 1932 TO 1951, INCLUSIVE, AND 1952

Cropping system	Average annual yields in bushels per acre				
	1932–36*	1937–41	1942–46	1947–51	1952
Continuous corn	23.9	32.5	23.9	17.8	103.0
Rotation	25.8	57.0	72.0	83.9	98.4

* Includes the drought years 1934 and 1936 when the crop was a failure.

5-year period, 24.5 for the second, 38.1 for the third, and 66.1 for the fourth.

When land is kept in cultivated row crops for any length of time the tendency is for yields to decline steadily, and in some cases rapidly. As cultivated row crops in a cropping system are replaced by sod crops, yields improve. Because of these facts the former crops have become known as soil-depleting and the latter as soil-improving. However, if we consider the amount of plant nutrients removed from the soil by these two groups of crops, we often find that the worst offenders in the soil-depleting group actually remove less plant nutrients than the soil-improving crops. This is especially true where stalks and other crop residues of the soil-depleting crops are left in the field.

This point may be illustrated by comparing the amount of plant nutrients removed by hay with the amount removed by the grain of the corn and oat crops in a 5-year rotation with 3 years of hay (12). The number of pounds per acre of calcium, phosphorus, nitrogen, and potassium contained in the grain of the corn and oat crops and the average pounds per acre of the same nutrients removed in hay for the 5-year rotation are given in Table II.

Except for nitrogen, the figures presented in Table II do not show corn to be soil-depleting in comparison with hay. Since the hay crop contained alfalfa, it is presumed that the nitrogen removed in the harvested hay was approximately equal to the amount taken from the air by the crop. Thus the original supply of nitrogen in the soil was not changed. However, the nitrogen removed by the corn crop was a net loss to the soil's supply.

This indicates that the so-called soil-depleting crops are really not depleting after all. Nor is the term "soil-improving" an accurate description of the crops in that group. More accurately (as will be shown later) the chief difference between these two groups is the amount of plant cover they provide and its influence on erosion and other de-

TABLE II.—AVERAGE POUNDS PER ACRE OF PLANT NUTRIENTS REMOVED ANNUALLY IN THE GRAIN OF CORN AND OAT CROPS AND ALFALFA-BROME HAY IN A 5-YEAR ROTATION OF CORN, OATS, HAY, HAY, HAY DURING THE PERIOD 1947-50

Crop	Calcium	Phosphorus	Nitrogen	Potassium
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
Corn	0.35	9.46	52.55	10.86
Oats	2.01	7.36	42.82	8.92
Hay	42.90	13.52	109.31	103.43

teriorating effects on the soil.

Soil and Water Losses

It is generally recognized that, under most systems of management, land cropped to grass and trees does not present as serious an erosion problem as land devoted to cultivated crops. In fact, erosion is practically nonexistent on land protected by ample plant cover, regardless of the kind and nature of the cover. Likewise, the loss of water as runoff is directly affected by the plant cover. As plant cover decreases or deteriorates, erosion and runoff losses become progressively higher (Table III).

TABLE III.—AVERAGE SOIL LOSS PER ACRE IN TONS AND RUNOFF IN PER CENT OF RAINFALL ANNUALLY OVER A 14-YEAR PERIOD (16)

Treatment	Soil	Runoff
Continuous bluegrass	.34	12.0
Rotation: corn, wheat, clover	2.78	13.8
Continuous wheat	10.09	23.3
Continuous corn	19.72	29.4
Fallow	41.65	30.7

The extent to which any cropping system is effective in reducing soil and water losses depends largely upon the protection of close-growing vegetation used and the length of time and season of the year it occupies the land. Crops that provide protective cover during the months of erosion-producing rains are especially valuable in conserving soil and water.

A crop rotation of cotton, wheat, and sweetclover reduced soil loss 74 per cent and runoff water 34 per cent annually, compared with continuous cotton during a 21-year period at Guthrie, Oklahoma (7). Both wheat and sweetclover greatly reduced erosion, but the amount of soil removed from the wheat plot was six times as great as from the sweetclover. During a 1.69-inch rain on July 21, 1950 (with 5-, 15-, and 30-minute intensities of 5.64, 3.84, and 2.30 inches per hour, respectively) the continuous cotton plot lost 41.65 per cent of the rainwater as runoff and 2.035 tons of soil per acre. The cotton plot in the rotation lost 39.40 per cent of the rainwater as runoff and 1.835 tons of soil per acre. The wheat plot lost 47.51 per cent of the rainfall as runoff and 0.098 ton of soil per acre. The sweetclover plot lost no water or soil and a Bermuda sod plot lost only 0.47 per cent runoff and no soil by erosion.

Land in Nebraska plowed the previous year and planted to corn lost almost twice as much water and four times as much soil as land that was subsurface-tilled and protected with wheat residues (8). Combined wheat stubble and straw left undisturbed on the soil surface reduced runoff loss to 2.39 of the rain that fell, and soil loss to 1 per cent of that on bare land. Land planted to oats after corn had been harvested, stalks removed, and land disked, lost 10.852 tons of soil per acre from January 1 to June 30, 1942. Adjacent plots with cornstalk residue and subtilled before planting oats lost 0.613 ton of soil. Plots planted to corn (after the preceding sweetclover crop had been turned under) lost 12.364 tons of soil from one rain. But an adjacent sweetclover plot which was subtilled before planting to corn lost only 1.152 tons of soil.

Land in Georgia planted continuously to cotton lost an average of 24.95 tons of soil per acre annually during the period 1940-47 (5). This rate of soil loss was reduced to 15.39 tons by using a 2-year rotation consisting of corn-crotalaria and cotton-vetch. A 3-year rotation of oats-lespedeza, lespedeza, and cotton reduced erosion still further to 3.38 tons per acre annually. Of the 10.15 tons per acre of soil lost during the three years of the rotation, 7.08 tons were lost during the year the land was cropped to cotton. Only 0.25 ton was lost during the year the land was in lespedeza.

Plots of Houston clay in Mississippi, covered with straw at the rate of 2 tons per acre immediately after cultivation, lost only 0.1 ton of soil per acre from July 1 to December 31, 1942 (30). During this period an adjacent plot which was cultivated but not covered with straw lost 21 tons of soil per acre. The straw-covered plot lost 6 per cent of the 14.83 inches of rain that fell, whereas the unmulched plot lost 44 per cent.

An annual average of 51 tons of soil per acre was lost from Shelby silt loam planted continuously to corn (20). But the rate of soil loss was reduced to an average of 9 tons per acre annually (or 80 per cent) when corn was grown in a 3-year rotation of corn, wheat, and red clover-timothy. During the same period an adjacent plot of bluegrass sod lost practically no soil.

The addition of wheat, red clover, and timothy to the cropping system provided better plant cover during the time they occupied the land. The continuous corn plot was practically bare, except for a brief period during the latter part of the corn-growing season. On the other hand, the rotation plots were protected by plant cover for a longer period of time. Here the land was protected by plant cover except for the portion of the year when corn was grown. Corn was followed by wheat in October. Timothy was either planted in the wheat in the fall or the next spring, and red clover was planted in the spring. After the wheat was harvested, the clover and timothy continued to furnish good cover throughout the remainder of the year and all through the third year of the rotation until April of the corn year, when the ground was plowed for corn. The effectiveness of plant cover in controlling erosion is illustrated in Figure 4.

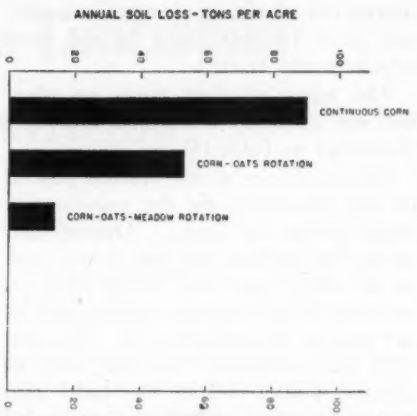

Fig. 4. Effect of cropping practices on erosion of Shelby silt loam.

Losses of Plant Nutrients

We have seen that there is a close and direct relation between plant cover and soil erosion. To provide efficient protection from raindrops, the plant cover must be dense and continuous.

However, the total amount of soil lost tells only part of the story. Soil erosion was shown to be a selective process (21, 22) since the soil lost from the field usually contains higher con-

TABLE IV.— AVERAGE POUNDS OF PLANT NUTRIENTS IN ERODED MATERIAL REMOVED PER ACRE ANNUALLY DURING A 2-YEAR PERIOD MAY 1, 1926 TO MAY 1, 1928 (16)

Treatment	Nitrogen	Phosphorus	Potassium	Magnesium	Calcium	Sulphur
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Continuous bluegrass	0.60	0.16	2.67	0.22	1.07	——
Rotation: corn, wheat, clover	26.36	6.20	213.86	29.18	86.08	5.97
Continuous wheat	32.39	9.42	264.00	42.67	106.23	8.55
Continuous corn	65.90	18.00	605.30	87.29	220.84	16.66
Fallow	118.13	37.75	1,245.55	171.94	458.51	46.72

centrations of silt, clay, organic matter, and plant nutrients than the soil from which it was eroded.

The effect of plant cover on plant nutrient losses by erosion is strikingly illustrated in Table IV.

The selectivity of the erosion process is well illustrated by the results of a single storm in Idaho. During this storm the surface soil lost 6 per cent of its silt, 7 per cent of its clay, 20 per cent of its organic matter, and 20 per cent of its nitrogen (6). The surface soil contained 3.05 per cent of organic matter before the hard rain and 2.44 after, whereas the eroded material contained 5.35 per cent.

Conserving Soil Organic Matter

Without adequate plant cover to protect the soil against the impact of falling raindrops, the organic matter of the soil is quickly removed by the erosion process (15). Without this protection it is difficult—if not impossible—to maintain, much less to build up, the organic matter content of the soil.

The importance of plant cover in controlling erosion and maintaining organic matter is illustrated by studies conducted on Shelby silt loam in Missouri during the 7-year period 1930 to 1937 (19). These studies showed that soil and organic matter losses from erosion were inversely proportional to the amount of plant cover maintained. For example, the organic matter content of soil kept in fallow declined from 3.76 to 2.49 per cent during this period, while that kept in sod increased from 3.65 to 3.91 per cent. The organic matter content of soil planted continuously to corn declined from 3.31 to 2.64 per cent, whereas that planted to a 3-year rotation of corn, wheat, and clover declined from 3.52 to 3.42 per cent.

The treatment which permitted the greatest loss of organic matter also suffered the greatest soil and humus losses (19). To illustrate, land kept in fallow lost a total of 12 tons of humus per acre during the 7-year period, along with 603 tons of soil. Land planted to corn continuously lost 7.4 tons of humus per acre in 371 tons of soil. Land planted to a 3-year rotation lost 39 tons of soil per acre compared with only 1.5 tons for adjacent land kept in sod.

It was estimated that 5.2 tons of clover hay per acre annually would be required to replace the humus lost from land kept in corn; 0.6 ton from unfertilized land cropped to a 3-year rotation; 0.4 ton from fertilized land planted to a 3-year rotation; and 9.2 tons from fallow land.

It was also estimated that if erosion were eliminated, the nitrogen content of the fallow soil (and presumably the organic matter content) could be maintained by the addition of half a ton of clover hay per acre annually (1), despite the fact that this amount was required to maintain the nitrogen and organic matter content on the 3-year rotation plots because of erosion losses. Based on the assumption that the organic matter content of the eroded material was the same as that of the parent soil, the fallow plot lost 18 times as much organic matter by erosion as by oxidation (19). However, during 1935 and 1937 the eroded material contained, on the average, at least 40 per cent more organic matter than the eroding soil (28). On the basis of these figures it would appear that the loss of organic matter by erosion was more than 25 times as great as that by oxidation.

The addition of 2.5 tons per acre annually over a 15-year period as a mulch of dried and chopped red clover to Shelby loam resulted in a net gain of 497 pounds of nitrogen (1). During the same period the nitrogen content of an adjacent area which received no clover declined a total of 115 pounds per acre. The soil on both plots was spaded in June of each year. After spading, the chopped clover was spread over the surface of one series of plots

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General Rules Concerning Plant Nutrients

By Arthur Wallace

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IT has been said that the best fertilizer is a grower's shadow. The grower is indeed of utmost importance, but effort alone will never totally replace good soil fertility. The two go hand in hand, as is implied in the verse:

"Early to bed, early to rise;
Work like ——, and fertilize!"

But this statement does not answer when, how much, or what to fertilize, or how management practices influence fertilizer response. The problems involved in the wise and economic use of fertilizers would be very much simpler if there were a set of guiding principles that would apply to all crops and to all soils. Unfortunately both crops and soils are too variable for much standardization in fertilizer practice. A set of rules of relatively wide applicability can be formulated concerning soil fertility and soil management. These include:

Rule 1—The production and profit of all crops can be increased by better management practices.

Rule 2—Nutrient deficiencies can be masked and can be induced by other limiting factors, including deficiencies and excesses of nutrients.

Rule 3—For most nutrient elements, no soil is inexhaustible.

Rule 4—Nitrogen fertilizer is nearly always needed regardless of the soil or of the crop.

Rule 5—The efficiency of utilization of fertilizers is usually low but can be increased by better management practices.

The recognition and use of these five generalizations could lead to more economy and better crop production. Each of these rules is discussed below. No originality is claimed for them and the contributions of many workers have been freely referred to.

Rule 1—The production and profit of all crops can be increased by better management practices. No reservations concerning this rule are offered except possibly for occasions of floods, droughts, freezes, or other acts of Nature. The average growth made by any plant is usually far less than its capacity to produce. Yields of 300 bushels an acre for corn and 1,000 bushels an acre for potatoes formerly were considered impossible, but are now within possibility. These are good examples of how changes in cultural practices can increase yields. It is seldom that cultural practices such as fertilization, use of better varieties, plant spacing, cultivation, use of soil amendments, irrigation, and pest and disease control cannot be improved.

The optimum plant is a theoretical entity since it is unlikely that all conditions necessary for plant growth are ever at an optimum value and in the correct balance at any one time. There are at least 27 environmental, including nutritional, factors that influence plant growth. Assuming each factor to be either at an optimum value or not at an optimum value and assuming all as independent factors, which they are not, the chance probability for the growth of any one plant to be maximum is $\frac{1}{2}^{27}$ or one chance in over 130 million. This statement is very much simplified and

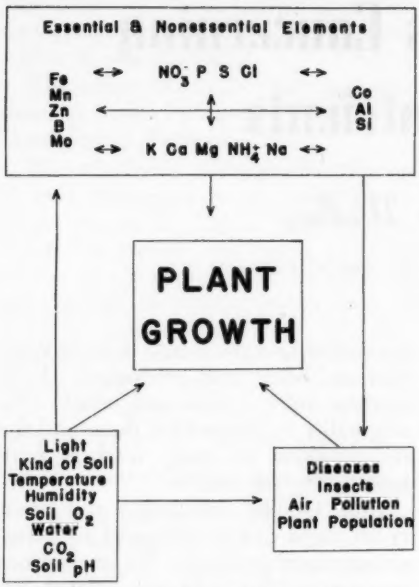

Fig. 1. There are at least 27 and probably more environmental factors simultaneously influencing growth of plants. Most of these factors are interrelated.

the probability is likely much too high. It does appear, however, that we are a long way from maximum yields and that there are plenty of chances for substantial yield increases through better management practices. Bradfield has estimated by using yields obtained by the best growers as 100 per cent that the average pasture and hay growers produce 25-35 per cent of their potentialities, corn growers 50-60 per cent, and potato growers 70-80 per cent. No one will doubt that even the better growers could increase their production.

Fortunately, plants are versatile enough that wide ranges of the environmental factors that influence growth are satisfactory for at least good production. The various factors that retard plant growth are thought of as limiting factors. These are discussed in Rule 2.

Rule 2—Nutrient deficiencies can be masked and can be induced by other limiting factors, including deficiencies and excesses of nutrients. Nutrient deficiencies are a very common type of limiting factor.

Deficiencies, whether in plants or in animals, are possibly the rule rather than the exception. The amount of growth is governed largely by the most limiting of the many factors influencing growth. Mother Nature is not necessarily interested in efficiency in the production of plants. The production of millions of seeds, pollen grains, or eggs results in relatively few plants or animals. Soil oxygen is believed to be almost always limiting for best root growth. Some plants will rapidly transpire themselves to death when water becomes limiting. The widespread nature of plant disorders means that several of them are always operating simultaneously. Most of the deficiencies present in any one plant, especially when slightly deficient, are masked by more pronounced deficiencies or by other aspects of the environment.

Each of the chemical reactions that occur in plants is related directly or indirectly to most all of the nutrient elements and environmental factors influencing growth. No nutrient element can act independently. In addition, a change in the relative rate of absorption of one nutrient element results in changes in the amount and distribution of most of the others. In recent years a branch of plant nutrition called nutrient-element balance has become very popular. It is concerned with antagonism and interrelationships of the various nutrients. Multiple deficiencies and nutrient-element balance have many practical considerations, as indicated in the following examples:

Excess potassium can induce magnesium deficiency, particularly if the magnesium status is borderline. The reverse has also been observed. Excess sodium, an unessential element, can help do the same thing. Excess phosphorus can induce iron deficiency. An excess of either iron or manganese can induce deficiency of the other. Excess nitrate nitrogen can result in diminished uptake of phosphorus and sulfur. The substitution of ammonium nitrogen for nitrate nitrogen can result in increased

uptake of phosphorus and sulfur. Excess chlorine, another unessential element, can result in a diminished uptake of nitrogen. Excess nitrogen can greatly aggravate a copper deficiency in tung trees. Tung trees supplied ammonium nitrogen need less calcium than when supplied nitrate nitrogen. In addition to these effects, magnesium-phosphorus, potassium-nitrogen, calcium-nitrogen, zinc-phosphorus, and calcium-boron interactions have been reported. These relationships can be illustrated by this example. In California there are some fruit trees that respond to potassium. Potassium applications in some cases where potassium need was very much indicated, however, have resulted in decreased yields. This resulted because a borderline magnesium deficiency existed and the extra potassium resulted in decreased magnesium absorption. The writer is not sure, but it is very likely that magnesium application without potassium would likewise have resulted in lower yields because of magnesium suppressing potassium absorption.

Research on limiting factors, including nutrients, at present is necessarily concerned with those that will result in relatively large production increases. The disorders that result in visible symptoms usually receive the most consideration. These major problems must be solved before the minor factors are even apparent. It is likely that partial deficiencies and partial toxicities are of greater economic importance than the visible ones. Even very minor disorders are important. Overcoming these may increase production only slightly, such as one per cent, but this could be of tremendous importance. A flat one per cent increase in all agricultural production in the United States would be valued at over 200 million dollars. Present research methods, however, are not sufficiently precise to detect one per cent yield increases.

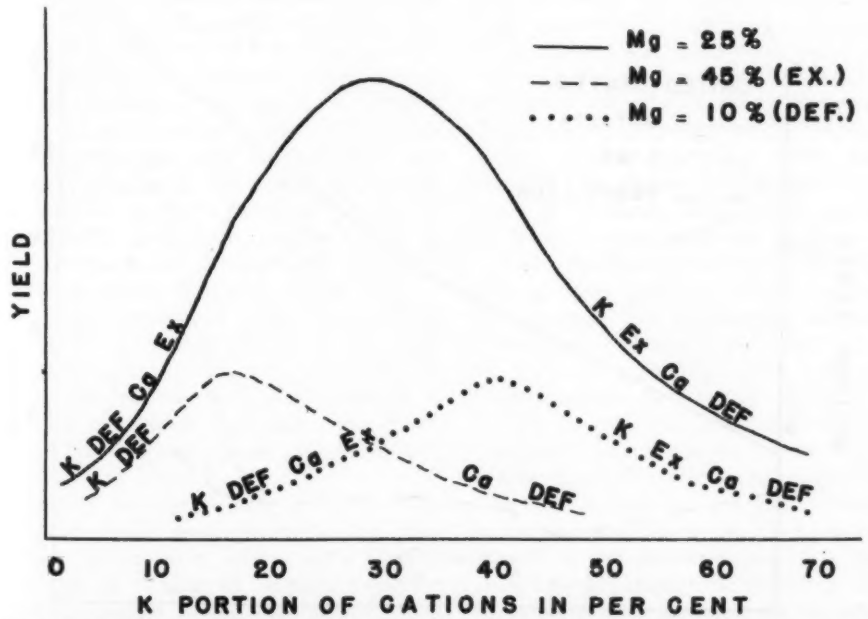

Fig. 2. The critical levels of any nutrient element are not usually constant. An important reason is the interaction of that element with other elements. These curves illustrate the possibility that the critical potassium level may be shifted either up or down, depending upon the levels of magnesium and calcium.

Fortunately good and profitable production can be obtained in spite of the multiplicity and interaction of limiting factors, and this becomes especially true as the more important problems are solved. An important need in plant research is to learn secrets of plant behavior, the functional aspects of the various nutrients, and the true nature of the soil. When we learn more of how plants behave and why, we shall have a much better chance of growing what we want.

Because of multiple deficiencies and the interrelations among nutrients in plant nutrition, the lack of response to a given nutrient does not mean that that element is not deficient. One can never be sure of negative results. For example, response to nitrogen cannot be expected if soil moisture is more limiting. The most limiting factor usually prevents entirely or retards greatly response to any less limiting factor. A certain large commercial fertilizer company almost insists on growers using a mixture of minor elements or none at all. The reasoning is perhaps justified in that one cannot expect much response to zinc if a greater deficiency exists for manganese. If several elements are applied simultaneously, the chances for getting response are considerably increased. Even this policy may not be safe, since toxic amounts of unused elements may easily build up in the soil.

Many early experiment station researches on fertilizer usage resulted in no response to the major fertilizer elements. Applications of 50-100 pounds per acre of 4-4-4 or similar low amounts gave no responses. Years later on the same soils fertilizer applications of 1,000-2,000 pounds per acre of 10-10-10

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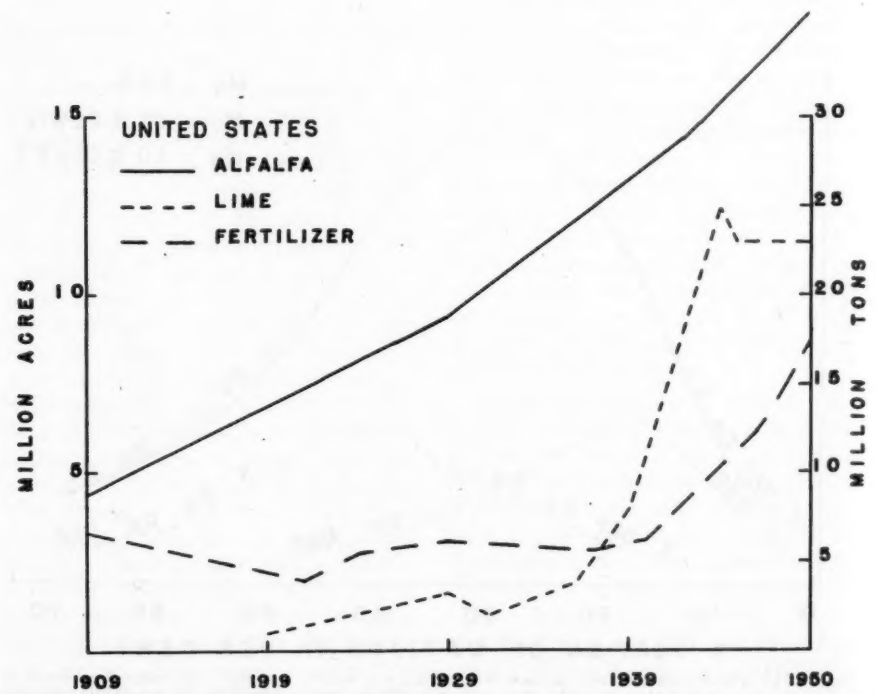

Fig. 3. Alfalfa acreage increases in the United States closely parallel the tonnages of lime and fertilizer used.

The Share of Crop Nutrients That Comes from Fertilizer

By H. C. Kuthe

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RAPID expansion in the use of commercial fertilizer during the last 12 years indicates that today the crops being grown in this country receive from commercial sources a substantially larger part of the total nutrients contained in them than was formerly the case. The purpose of this article is to ascertain how far this trend has advanced.

Unfortunately, the task cannot be discharged in an exact manner, mainly because it is impossible accurately to ascertain how many nutrients are contained in the plants pastured off the land. It is doubtless possible, however, at least to estimate the quantities concerned; while for the various nutrients contained in harvested crops, certain data assembled by the U. S. Department of Agriculture exist. These data cover the year 1947 but have been carried forward by the author in a rough manner to the fertilizer season of 1950/51 and been supplemented by allowances for the nutrients contained in the plants pastured off the land.

The results of these calculations, which have been limited to the three major plant foods, are presented, together with data for the quantity of each plant food that during the season of 1950/51 came from commercial fertilizer, in Table I.

The tonnage figures in Table I become much more meaningful if they are placed on a ratio basis. This is done in Table II, which expresses the quantity of the commercial plant food applied to each crop as a per cent of the total nitrogen, phosphoric oxide, or potash contained in the crop concerned.

The ratio figures offered in Table II show enormous variations. In an attempt at explaining them, look first at the data for nitrogen. They range from as high as 95 or 96 per cent in the case of tobacco or of vegetables and fruits to as low as 3 per cent regarding hay and pasture. The very high figures for vegetables and the related products must be principally explained, of course, through the fact that these crops are nearly always grown on rather light soils in the humid sections of the country where the organic content has long ago been lost through oxidation. Furthermore, the crops here under review are frequently raised by farmers who have little or no livestock and grow only limited quantities of leguminous crops. Hence vegetables, fruits, and tobacco can obtain the nitrogen they need, in substance, only if it is applied in the form of commercial fertilizer.

The opposite situation prevails in the case of small grains as well as of hay and pasture. For appreciating the very low figures (12 and 3 per cent) listed in Table II regarding these crops it should mainly be kept in mind that wheat, the principal small grain in the country, is largely grown on the Great Plains where Nature has accumulated enormous quantities of organic matter in the soil and where the cold winters as well as the semi-arid climate of the region greatly restrict the oxidation and the subsequent leaching of the nitrogen contained in these organics. Since the semi-arid climate in addition severely

limits the yields, each crop of wheat removes only small quantities of soil nitrogen and the supply of this factor still is, therefore, so ample that only little need exists for commercial nitrogen. Oats, on the other hand, are principally grown in the Corn Belt together with a leguminous crop and they receive from this source, as well as from manure, nearly all of the nitrogen contained in them. The result of these and of certain other facts is that for small grains as a whole Table II carries a ratio figure of only 12 per cent. The still lower figure applying to hay and pasture is explained through the fact that hay crops and pastures frequently contain many legumes or are not fertilized very intensively.

Finally, for corn and cotton Table II lists intermediate ratio figures of 30 and 62 per cent. In the case of corn the figure in question is due, of course, to the facts that the extensive growing of legumes in the Corn Belt as well as the rather liberal use of manure in that region always supply to corn much nitrogen and that consequently only a restricted need exists for the commercial product although this need is rapidly expanding.

With respect to cotton, on the other hand, the intermediary figure of 62 per cent listed in Table II must be principally explained through the fundamental differences which exist between

(*Turn to page* 49)

TABLE I.—PLANT-FOOD CONTENT OF THE VARIOUS CROPS AND NUTRIENTS SUPPLIED AS COMMERCIAL FERTILIZER, SEASON OF 1950/51 *

(Continental United States only—in short tons of each plant food)

	Nitrogen		Phosphoric Oxide		Potash	
	1 Total contained in crop	2 Supplied as fertilizer	3 Total contained in crop	4 Supplied as fertilizer	5 Total contained in crop	6 Supplied as fertilizer
Corn	1,400,000	415,000	480,000	455,000	600,000	421,000
Small grains	1,200,000	142,000	230,000	430,000	280,000	226,000
Cotton	460,000	285,000	190,000	140,000	375,000	108,000
Vegtables, incl. potatoes, and fruits	220,000	212,000	170,000	294,000	250,000	236,000
Tobacco	38,000	36,000	5,000	74,000	58,000	58,000
Hay and pasture	3,200,000	100,000	825,000	605,000	2,140,000	229,000
Other crops	782,000	25,000	200,000	88,000	397,000	60,000
Total	7,300,000	1,215,000	2,100,000	2,086,000	4,100,000	1,338,000

* Source: For developing the figures in col.'s 1, 3, and 5 the author basically used the data published in *Agricultural Chemicals*, issues of Oct. and Nov., 1949, by A. L. Mehring and R. Q. Parks of the U. S. Department of Agriculture for the plant food removed from the soil during 1947 in 100 principal crops harvested in the Continental United States; these figures, which read 5.2 million tons for nitrogen, 1.8 million tons for phosphoric oxide, and 3.1 million tons for potash, have been roughly carried forward by the author to the fertilizer season of 1950/51 and been supplemented by allowances for the plants pastured off the land; the results should be considered only approximations; this especially applies to the figures listed for vegetables and fruits, hay or pasture, and "other" crops since it was impossible for the author to develop these figures in an exact manner.

The aggregates listed in the bottom line of col.'s 2, 4, and 6 for the quantity of each plant food that was supplied as commercial fertilizer are, basically, the estimates of the U. S. Department of Agriculture as prepared by Walter Scholl and H. M. Wallace and published in the *Commercial Fertilizer*, issue of June, 1952 The author has added, however, 44,000 tons to the figure given for nitrogen in that article in order to cover certain quantities not reached in the inquiry of the Department; unfortunately, it was impossible to make a similar correction for phosphoric oxide and potash.

The breakdown over crops of the aggregate figures just discussed represents estimates of the author which have been prepared in part with the help of various data published by the Department of Agriculture.

It should be noted that no allowances have been made for losses from leaching or erosion, which doubtless were in part significant.

PICTORIAL

A Tropical Vista

A Study

of

Clouds—

Reveals

Nature's

Artistry

Above: Morning on the Farm

Below: A Quiet Shoreline

The Editors Talk

Our Cover Picture

The big birch tree in the cover illustration seems to be hovering over the young pines surrounding it like a foster parent. And, indeed, that is just what it is.

This relationship was discovered when it was noticed that pine seedlings and saplings growing under the crown of birch trees in the Adirondack Mountains were much bigger and healthier than those growing in the open. Why? Seeking an answer, investigators analyzed soils and the foliage of birch and pines in both locations. Much more exchangeable potassium and acid-soluble phosphorus were found in the soils under the birch-pine groups than in the open. Foliage from pines under the birches contained almost twice as much potassium as that from pines grown in the open.

With these facts established, the explanation seemed clear. The birch with its strong root system "pumps" the potash from the lower soil levels. This potash is then made available in upper soil levels through the decomposition of birch foliage. Young pines, therefore, grow well and thrive under birch trees.

More detailed information on this experiment and the significance of the results will be found in the article by Laurence C. Walker, "White Birch Helps Restore Potash-deficient Forest Soils," starting on page 11 of this issue.

Another Year

Another year of prosperity is being checked up for American agriculture. While final net income will not equal that of last year, volume of marketings from fewer acres is greater. This, despite the severe drought that hit a large part of the country, speaks well for the capacity of our farms and farmers to produce.

The Agricultural Marketing Service, U. S. Department of Agriculture, reports that farm marketing receipts for the first 11 months of 1953 totaled $28.1 billions, 4 per cent below the figure for the corresponding period of 1952. Cash receipts for livestock and products were down 8 per cent; income from eggs and poultry, up 8 per cent. Crop receipts were virtually the same for both 11-month periods.

Although farm income from marketings was down 4 per cent, prices paid by farmers for the goods and services they buy were running only 2 per cent below a year ago, as of November 15. It should be pointed out that the farmer's realized net income depends upon what he must pay out as well as upon what he receives.

Net realized farm income this year is expected to be about $12.5 billions, almost exactly what it was in 1950—a good year for agriculture. During 1952, net

income dropped more than $1 billion from the preceding year as prices receded from the Korean War peaks reached in 1951.

It is expected that final figures will show the decline this year to be less than $1 billion, as prices have leveled off in recent months. Actually, total cash receipts of farmers in November were slightly higher than they were in the same month of 1952 and December may show a similar trend.

The December release of the USDA Crop Reporting Board states that with harvest practically completed, this year's volume of crops is virtually equal to the second-largest total produced in 1952, despite the drought. The acreage from which crops were harvested was smaller than average, but yields per acre, in the aggregate, were record high. Harvest was completed rapidly under favorable to ideal conditions, both for small grains and later-maturing crops. With few exceptions, quality was good to excellent.

Over 359 million acres of the 59 principal crops were planted or grown in 1953. This was 3.1 million acres more than in 1952 and slightly more than average. Contributing to this larger planted acreage of crops was the sizable abandoned acreage of winter wheat replanted to sorghums or other spring crops. Compared with last year, acreages were smaller for corn, cotton, and hay; but larger for most other crops, particularly oats, flax, and sorghums.

Nearly 340½ million acres of crops were harvested in 1953. This is 1.4 million less than in 1952 and more than 4 million below the 1942-51 average.

The harvested acreage of winter wheat was 4 million less than in 1952. The 1953 crop totaled 878 million bushels, a surprisingly large outturn considering the unfavorably dry conditions over practically the entire country at seeding time in the fall of 1952. The 1953 crop topped the average by 10 per cent or 80 million bushels, but was a sixth less than the record crop of 1,060 million bushels harvested in 1952. This year's crop was the fourth largest winter wheat crop on record.

The harvested acreage of cotton was 1.4 million less than in 1952, but a crop of 16,437,000 bales, the fourth largest of record, is estimated for 1953. This compares with 15,139,000 bales in 1952 and 15,149,000 in 1951. This is the first time production has exceeded 15 million bales in three consecutive years. The 10-year average production is 12,216,000 bales.

The harvested acreage of corn was 0.8 million less than in 1952. The yield is the fifth largest of record and 5 per cent larger than average, but 3 per cent smaller than last year's near-record crop.

The harvested acreage of all hay was 0.5 million acres less than in 1952. Hay crops produced a large total tonnage in 1953 despite the summer drought and more than usual diversion of hay acreage to pasture. The total crop of 105.3 million tons, which has been exceeded in only three other years, was harvested from 73.9 million acres, an area slightly below average. The yield of 1.42 tons per acre of all hay is the third highest of record.

Utilization of improved farming practices helped farmers meet the problems of readjustment that developed during the year. Mechanization helped with labor problems. Improved varieties and better quality seeds along with the increased use of fertilizers were big factors in realizing the high acre yields obtained in spite of adverse weather conditions. The relatively low cost of fertilizers and improved application techniques helped immeasurably in reducing the unit cost of production and took some of the pressure off the price-cost squeeze the farmers are now facing.

Season Average Prices Received by Farmers for Specified Commodities *

Crop Year	Cotton Cents per lb. Aug.-July	Tobacco Cents per lb.	Potatoes Cents per bu. July-June	Sweet Potatoes Cents per bu. July-June	Corn Cents per bu. Oct.-Sept.	Wheat Cents per bu. July-June	Hay [1] Dollars per ton July-June	Cottonseed Dollars per ton July-June	Truck Crops ....
Av. Aug. 1909–July 1914....	12.4	10.0	69.7	87.8	64.2	88.4	11.87	22.55	....
1927.....	20.2	20.7	101.9	109.0	85.0	119.0	10.29	34.83	....
1928.....	18.0	20.0	53.2	118.0	84.0	99.8	11.22	34.17	....
1929.....	16.8	18.3	131.6	117.1	79.9	103.6	10.90	30.92	....
1930.....	9.5	12.8	91.2	108.1	59.8	67.1	11.06	22.04	....
1931.....	5.7	8.2	46.0	72.6	32.0	39.0	8.69	8.97	....
1932.....	6.5	10.5	38.0	54.2	31.9	38.2	6.20	10.33	....
1933.....	10.2	13.0	82.4	69.4	52.2	74.4	8.09	12.88	....
1934.....	12.4	21.3	44.6	79.8	81.5	84.8	13.20	33.00	....
1935.....	11.1	18.4	59.3	70.3	65.5	83.2	7.52	30.54	....
1936.....	12.4	23.6	114.2	92.9	104.4	102.5	11.20	33.36	....
1937.....	8.4	20.4	52.9	78.0	51.8	96.2	8.74	19.51	....
1938.....	8.6	19.6	55.7	69.8	48.6	56.2	6.78	21.79	....
1939.....	9.1	15.4	69.7	73.4	56.8	69.1	7.94	21.17	....
1940.....	9.9	16.0	54.1	85.4	61.8	68.2	7.59	21.73	....
1941.....	17.0	26.4	80.8	92.2	75.1	94.4	9.70	47.65	....
1942.....	19.0	36.9	117.0	118.0	91.7	110.0	10.80	45.61	....
1943.....	19.9	40.5	131.0	206.0	112.0	136.0	14.80	52.10	....
1944.....	20.7	42.0	150.0	190.0	109.0	141.0	16.50	52.70	...
1945.....	22.5	36.6	143.0	204.0	127.0	150.0	15.10	51.10	....
1946.....	32.6	38.2	124.0	218.0	156.0	191.0	16.70	72.00	....
1947.....	31.9	38.0	162.0	217.0	216.0	229.0	17.60	85.90	....
1948.....	30.4	48.2	155.0	222.0	129.0	200.0	18.45	67.20	....
1949.....	28.6	45.9	128.0	214.0	124.0	188.0	16.50	43.40	....
1950.....	40.1	51.7	91.7	173.0	153.0	200.0	16.70	86.50	....
1951.....	37.9	51.2	163.0	306.0	168.0	211.0	19.50	69.30	....
1952									
December....	31.71	49.6	199.0	362.0	150.0	212.0	21.65	68.50	....
1953									
January.....	29.79	46.2	206.0	386.0	148.0	210.0	21.65	65.30	....
February....	30.19	36.7	179.0	384.0	143.0	205.0	20.85	64.50	....
March.....	31.52	....	165.0	401.0	146.0	210.0	19.65	63.60	....
April.....	31.45	....	134.0	409.0	146.0	208.0	18.85	63.10	....
May.....	31.73	51.5	115.0	413.0	149.0	206.0	17.95	61.80	....
June.....	31.51	51.0	102.0	398.0	146.9	188.0	16.05	61.20	....
July.....	31.87	51.2	95.5	402.0	147.0	187.0	15.45	59.00	....
August.....	32.77	51.3	91.4	350.0	148.0	186.0	15.85	56.70	....
September...	33.09	57.6	98.9	264.0	150.0	192.0	16.15	51.50	....
October.....	32.46	52.6	89.7	233.0	134.0	194.0	16.45	52.40	....
November...	31.82	42.3	91.6	232.0	133.0	200.0	17.25	53.40	....
Index Numbers (Aug. 1909—July 1914 = 100)									
1927.....	163	207	146	124	132	135	87	154	127
1928.....	145	200	76	134	131	113	95	152	154
1929.....	135	183	189	133	124	117	92	137	137
1930.....	77	128	131	123	93	76	93	98	129
1931.....	46	82	66	83	50	44	73	40	115
1932.....	52	105	55	62	50	43	52	46	102
1933.....	82	130	118	79	81	84	68	57	91
1934.....	100	213	64	91	127	96	111	146	95
1935.....	90	184	85	80	102	94	63	135	119
1936.....	100	236	164	106	163	116	94	148	104
1937.....	68	204	76	89	81	109	74	87	110
1938.....	69	196	80	79	76	64	57	97	88
1939.....	73	154	100	84	88	78	67	94	91
1940.....	80	160	78	97	96	77	64	96	111
1941.....	137	264	116	105	117	107	82	211	129
1942.....	153	369	168	134	143	124	91	202	163
1943.....	160	405	188	235	174	154	125	231	245
1944.....	167	420	214	216	170	160	139	234	212
1945.....	181	366	205	232	198	170	127	227	207
1946.....	263	382	178	248	212	209	141	319	182
1947.....	257	380	232	248	336	259	148	381	226
1948.....	245	482	222	253	201	226	155	298	214
1949.....	231	459	184	244	193	213	139	192	201
1950.....	323	517	132	197	238	226	141	384	185
1951.....	306	512	233	349	262	239	164	307	239
1952									
December....	256	496	286	412	234	240	182	304	256
1953									
January.....	240	462	296	440	231	238	182	290	237
February....	243	367	257	437	223	232	176	286	237
March.....	254	...	237	457	227	238	166	282	248
April.....	254	...	192	466	227	235	159	280	204
May.....	256	515	165	470	232	233	151	274	182
June.....	254	510	146	453	227	213	138	271	270
July.....	257	512	137	458	229	212	130	262	216
August.....	264	513	131	399	231	210	134	251	221
September...	267	576	142	301	234	217	136	228	159
October.....	262	526	129	265	209	219	139	232	175
November...	257	423	131	264	207	226	145	237	186

Wholesale Prices of Ammoniates **

	Nitrate of soda bulk per unit N	Sulphate of ammonia bulk per unit N	Cottonseed meal S. E. Mills per unit N	Fish scrap, dried 11–12% ammonia, 15% bone phosphate, f.o.b. factory bulk per unit N	Tankage 11% ammonia, 15% bone phosphate, f.o.b. Chicago, bulk, per unit N	High grade ground blood, 16–17% ammonia, Chicago, bulk, per unit N
1910–14	$2.68	$2.85	$3.50	$3.53	$3.37	$3.52
1927	3.01	2.26	5.07	5.87	4.32	5.70
1928	2.67	2.30	7.06	6.63	4.92	6.00
1929	2.57	2.04	5.64	5.00	4.61	5.72
1930	2.47	1.81	4.78	4.96	3.79	4.58
1931	2.34	1.46	3.10	3.95	2.11	2.46
1932	1.87	1.04	2.18	2.18	1.21	1.36
1933	1.52	1.12	2.95	2.86	2.06	2.46
1934	1.52	1.20	4.46	3.15	2.67	3.27
1935	1.47	1.15	4.59	3.10	3.06	3.65
1936	1.53	1.23	4.17	3.42	3.58	4.25
1937	1.63	1.32	4.91	4.66	4.04	4.80
1938	1.69	1.38	3.69	3.76	3.15	3.53
1939	1.69	1.35	4.02	4.41	3.87	3.90
1940	1.69	1.36	4.64	4.36	3.33	3.39
1941	1.69	1.41	5.50	5.32	3.76	4.43
1942	1.74	1.41	6.11	5.77	5.04	6.76
1943	1.75	1.42	6.30	5.77	4.86	6.62
1944	1.75	1.42	7.68	5.77	4.86	6.71
1945	1.75	1.42	7.81	5.77	4.86	6.71
1946	1.97	1.44	11.04	7.38	6.60	9.33
1947	2.50	1.60	12.72	10.66	12.63	10.46
1948	2.86	2.03	12.94	10.59	10.84	9.85
1949	3.15	2.29	10.11	13.18	10.73	10.62
1950	3.00	1.95	11.01	11.70	10.21	9.36
1951	3.16	1.97	13.20	10.92	10.18	10.09
1952						
December	3.34	2.26	13.20	11.24	9.95	9.17
1953						
January	3.34	2.28	13.25	11.24	8.43	8.05
February	3.34	2.28	13.21	11.24	7.75	7.28
March	3.34	2.28	12.69	11.24	7.16	6.56
April	3.34	2.28	11.75	11.24	6.07	6.00
May	3.34	2.28	10.34	11.24	6.23	6.14
June	3.34	2.28	10.61	11.26	6.62	6.31
July	3.34	2.28	10.34	11.15	6.75	6.14
August	3.34	2.28	10.14	10.95	7.53	6.68
September	3.09	2.28	9.82	11.04	7.51	6.91
October	3.09	2.25	9.73	11.24	7.96	7.75
November	3.09	2.22	9.61	11.24	8.19	8.19
	Index Numbers (1910-14 = 100)					
1927	112	79	145	166	128	162
1928	100	81	202	188	146	170
1929	96	72	161	142	137	162
1930	92	64	137	141	112	130
1931	88	51	89	112	63	70
1932	71	36	62	62	36	39
1933	59	39	84	81	97	71
1934	59	42	127	89	79	93
1935	57	40	131	88	91	104
1936	59	43	119	97	106	131
1937	61	46	140	132	120	122
1938	63	48	105	106	93	100
1939	63	47	115	125	115	111
1940	63	48	133	124	99	96
1941	63	49	157	151	112	126
1942	65	49	175	163	150	192
1943	65	50	180	163	144	189
1944	65	50	219	163	144	191
1945	65	50	223	163	144	191
1946	74	51	315	209	196	265
1947	93	56	363	302	374	297
1948	107	71	370	300	322	280
1949	117	80	289	373	318	302
1950	112	68	315	331	303	266
1951	118	69	377	310	302	287
1952						
December	125	79	377	318	295	261
1953						
January	125	80	379	318	250	229
February	125	80	378	318	230	207
March	125	80	363	318	212	186
April	125	80	336	318	180	170
May	125	80	295	318	185	174
June	125	80	303	319	196	179
July	125	80	295	316	200	174
August	125	80	290	310	223	190
September	115	80	281	313	223	196
October	115	79	278	318	236	220
November	115	78	275	318	243	233

Wholesale Prices of Phosphates and Potash **

	Superphosphate, Baltimore, per unit	Florida land pebble, 68% f.o.b. mines, bulk, per ton	Tennessee phosphate rock, 75% f.o.b. mines, bulk, per ton	Muriate of potash bulk, per unit, c.i.f. Atlantic and Gulf ports[1]	Sulphate of potash in bags, per unit, c.i.f. Atlantic and Gulf ports[1]	Sulphate of potash magnesia, per ton, c.i.f. Atlantic and Gulf ports[1]	Manure salts bulk, per unit, c.i.f. Atlantic and Gulf ports[1]
1910–14	$0.536	$3.61	$4.88	$0.714	$0.953	$24.18	$0.657
1927	.525	3.09	5.50	.646	.924	25.55	.586
1928	.580	3.12	5.50	.669	.957	26.46	.607
1929	.609	3.18	5.50	.672	.962	26.59	.610
1930	.542	3.18	5.50	.681	.973	26.92	.618
1931	.485	3.18	5.50	.681	.973	26.92	.618
1932	.458	3.18	5.50	.681	.963	26.90	.618
1933	.434	3.11	5.50	.662	.864	25.10	.601
1934	.487	3.14	5.67	.486	.751	22.49	.483
1935	.492	3.30	5.69	.415	.684	21.44	.444
1936	.476	1.85	5.50	.464	.708	22.94	.505
1937	.510	1.85	5.50	.508	.757	24.70	.556
1938	.492	1.85	5.50	.523	.774	15.17	.572
1939	.478	1.90	5.50	.521	.751	24.52	.570
1940	.516	1.90	5.50	.517	.730	24.75	.573
1941	.547	1.94	5.64	.522	.780	25.55	.367
1942	.600	2.13	6.29	.522	.810	25.74	.205
1943	.631	2.00	5.93	.522	.786	25.35	.195
1944	.645	2.10	6.10	.522	.777	25.35	.195
1945	.650	2.20	6.23	.522	.777	25.35	.195
1946	.671	2.41	6.50	.508	.769	24.70	.190
1947	.746	3.05	6.60	.432	.706	18.93	.195
1948	.764	4.27	6.60	.397	.681	14.14	.195
1949	.770	3.88	6.22	.397	.703	14.14	.195
1950	.763	3.83	5.47	.371	.716	14.33	.195
1951	.813	3.98	5.47	.401	.780	15.25	.200
1952							
December	.860	3.98	5.47	.427	.827	16.00	.210
1953							
January	.860	3.98	5.47	.430	.827	16.00	.210
February	.860	3.98	5.47	.430	.827	16.00	.210
March	.860	4.22	5.47	.430	.827	16.00	.210
April	.860	4.28	....	.430	.827	16.00	.210
May	.860	4.28	....	.430	.827	16.00	.210
June	.860	4.28	....	.361	.708	13.44	.176
July	.895	4.28	....	.396	.768	14.72	.193
August	.895	....	....	.396	.768	14.72	.193
September	.895	....	....	.396	.768	14.72	.193
October	.895	....	....	.396	.768	14.72	.193
November	.895	....	....	.396	.768	14.72	.193
	Index Numbers (1910-14 = 100)						
1927	100	86	113	90	97	106	89
1928	108	86	113	94	100	109	92
1929	114	88	113	94	101	110	93
1930	101	88	113	95	102	111	94
1931	90	88	113	95	102	111	94
1932	85	88	113	95	101	111	94
1933	81	86	113	93	91	104	91
1934	91	87	110	68	79	93	74
1935	92	91	117	58	72	89	68
1936	89	51	113	65	74	95	77
1937	95	51	113	71	79	102	85
1938	92	51	113	73	81	104	87
1939	89	53	113	73	79	101	87
1940	96	53	113	72	77	102	87
1941	102	54	110	73	82	106	87
1942	112	59	129	73	85	106	84
1943	117	55	121	73	82	105	83
1944	120	58	125	73	82	105	83
1945	121	61	128	73	82	105	83
1946	125	67	133	71	81	102	82
1947	139	84	135	70	74	78	83
1948	143	118	135	67	72	58	83
1949	144	108	128	67	74	58	83
1950	142	106	112	68	75	59	83
1951	152	110	112	72	82	63	83
1952							
December	160	110	112	75	87	66	85
1953							
January	160	110	112	76	87	66	85
February	160	110	112	76	87	66	85
March	160	117	112	76	87	66	85
April	160	119	...	76	87	66	85
May	160	119	...	76	87	66	85
June	160	119	...	66	74	56	80
July	167	119	...	71	81	61	82
August	167	...	...	71	81	61	82
September	167	...	...	71	81	61	82
October	167	...	...	71	81	61	82
November	167	...	...	71	81	61	82

Combined Index Numbers of Prices of Fertilizer Materials, Farm Products and all Commodities

	Farm prices*	Prices paid by farmers for commodities bought*	Wholesale prices of all commodities†	Fertilizer material‡	Chemical ammoniates	Organic ammoniates	Superphosphate	Potash**
1927.....	141	148	139	116	89	150	100	94
1928.....	149	152	141	121	87	177	108	97
1929.....	148	150	139	114	79	146	114	97
1930.....	125	140	126	105	72	131	101	99
1931.....	87	119	107	83	62	83	90	99
1932.....	65	102	95	71	46	48	85	99
1933.....	70	104	96	70	45	71	81	95
1934.....	90	118	109	72	47	90	91	72
1935.....	109	123	117	70	45	97	92	63
1936.....	114	123	118	73	47	107	89	69
1937.....	122	130	126	81	50	129	95	75
1938.....	97	122	115	78	52	101	92	77
1939.....	95	121	112	79	51	119	89	77
1940.....	100	122	115	80	52	114	96	77
1941.....	123	130	127	86	56	130	102	77
1942.....	158	149	144	93	57	161	112	77
1943.....	192	165	151	94	57	160	117	77
1944.....	196	174	152	96	57	174	120	76
1945.....	206	180	154	97	57	175	121	76
1946.....	234	197	177	107	62	240	125	75
1947.....	275	231	222	130	74	362	139	72
1948.....	285	250	241	134	89	314	143	70
1949.....	249	240	226	137	99	319	144	70
1950.....	256	246	236	132	89	314	142	72
1951.....	302	271	263	139	93	331	152	76
1952								
December..	269	267	246	146	101	329	160	79
1953								
January...	267	267	246	144	102	307	160	80
February..	263	264	246	142	102	296	160	80
March....	264	265	248	141	102	282	160	80
April.....	259	264	246	139	102	256	160	80
May.....	261	264	247	137	102	245	160	80
June.....	259	260	246	135	102	253	160	70
July.....	259	261	248	138	102	252	167	75
August....	258	262	249	139	102	261	167	75
September.	256	259	249	137	97	258	167	75
October...	250	258	247	137	96	265	167	75
November.	249	259	247	137	96	267	167	75

* U. S. D. A. figures, revised January 1950. Beginning January 1946 farm prices and index numbers of specific farm products revised from a calendar year to a crop-year basis. Truck crops index adjusted to the 1924 level of the all-commodity index.

† Department of Labor index converted to 1910-14 base.

‡ The Index numbers of prices of fertilizer materials are based on original study made by the Department of Agricultural Economics and Farm Management, Cornell University, Ithaca, New York. These indexes are complete since 1897. The series was revised and reweighted as of March 1940 and November 1942.

[1] Beginning July 1949, baled hay prices reduced by $4.75 a ton to be comparable to loose hay prices previously quoted.

[2] All potash salts now quoted F.O.B. mines only; manure salts since June 1941, other carriers since June 1947.

**** Where range of prices for fertilizer material is quoted, average figure is used. The weighted average of prices actually paid for potash is lower than the annual average because since 1926 over 90% of the potash used in agriculture has been contracted for during the discount period. The maximum discount is now 16%. Applied to muriate of potash, a price slightly above $.353 per unit K_2O thus more nearly approximates the annual average than do prices based on arithmetical averages of monthly quotations.**

REVIEWS

This section contains a short review of some of the most practical and important bulletins, and lists all recent publications of the United States Department of Agriculture, the State Experiment Stations, and Canada, relating to Fertilizers, Soils, Crops, and Economics. A file of this department of BETTER CROPS WITH PLANT FOOD would provide a complete index covering all publications from these sources on the particular subjects named.

Fertilizers

"Fertilizers for Cereal, Hay, and Pasture Crops," Ontario Dept. of Agr., Toronto, Canada, Cir. 144, Rev. Aug. 1953, The Advisory Fertilizer Board of Ontario.

"Fertilizer Guide," Maritime Fertilizer Council, Moncton, N. B., Canada, J. E. McIntyre.

"Production, Composition and Costs of Handling Farm Manure on Central Indiana Farms," Agr. Exp. Sta., Purdue Univ., Lafayette, Ind., Sta. Bul. 593, July 1953, R. H. Bauman and J. M. Fitzpatrick.

"Inspection of Commercial Fertilizers," Agr. Exp. Sta., Purdue Univ., Lafayette, Ind., Sta. Cir. 396, April 1953.

"Effect of Foliar Applications of Urea, Sucrose, and Dextrose on Tomato Yields and Quality," Agr. Exp. Sta., Univ. of Ky., Lexington, Ky., Bul. 595, April 1953, J. E. Klinker and E. M. Emmert.

"Fertilizer Recommendations for Michigan Crops," Agr. Ext. Serv., Mich. State College, East Lansing, Mich., Ext. Bul. 159, Rev. June 1953, The Departments of Soil Science and Horticulture.

"Lime . . . The Farmer's Friend," Agr. Ext. Serv., Miss. State College, State College, Miss., Pub. 273, Aug. 1953, L. E. Gholston and U. S. Jones.

"Commercial Fertilizer Results with Winter Wheat and Rye, 1953," Agr. Exp. Sta., Univ. of Neb., Lincoln, Neb., Outstate Testing Cir. 30, Aug. 1953, G. W. Lowrey, R. A. Olson, A. F. Dreier, and P. L. Ehlers.

"Commercial Fertilizer Results with Oats, Barley, and Spring Wheat," Agr. Exp. Sta., Univ. of Neb., Lincoln, Neb., Outstate Testing Cir. 32, Sept. 1953, G. W. Lowrey, R. A. Olson, A. F. Dreier, and P. L. Ehlers.

"Commercial Feeds, Commercial Fertilizers, Economic Poisons, 1952 Report," State Laboratories Commission, Bismarck, N. Dak., Bul. No. 102, July 1953, R. O. Baird.

"Inspection and Analysis of Commercial Fertilizers," Agr. Exp. Sta., Clemson Agr. College, Clemson, S. C., Bul. 408, Oct. 1953, B. D. Cloaninger.

"Analyses of Commercial Fertilizers Sold During 1952-53," Agr. Exp. Sta., Texas A&M College, College Station, Texas, Bul. 772, Sept. 1953, J. F. Fudge and T. L. Ogier.

"Sources of Phosphoric Acid as Influencing the Yield and Chemical Composition of Pasture Forage on Lake Charles Clay Loam Soil," Agr. Exp. Sta., Texas A&M College, College Station, Texas, Prog. Rpt. 1587, June 3, 1953, R. M. Weihing, R. L. Cheaney, and L. C. Kapp.

"Effect of Different Nutrient Levels on the Yield of Marketable Black Diamond Watermelons, 1949-52," Agr. Exp. Sta., Texas A&M College, College Station, Texas, Prog. Rpt. 1589, June 9, 1953, G. L. Smith and H. C. Mohr.

"Distribution of Fertilizer Sales in Texas, January 1-June 30, 1953," Agr. Exp. Sta., Texas A&M College, College Station, Texas, Prog. Rpt. 1605, Aug. 28, 1953, J. F. Fudge.

"Effect of Fertilizers on the Yield and Grade of Onions," Agr. Exp. Sta., Texas A&M College, College Station, Texas, Prog. Rpt. 1608, Aug. 16, 1953, H. W. Gausman, W. R. Cowley, P. W. Leeper, and R. T. Correa.

"Fertilizer Requirements of Carrots in the Winter Garden," Agr. Exp. Sta., Texas A&M College, College Station, Texas, Prog. Rpt. 1611, Sept. 14, 1953, G. A. Buffington and D. R. Paterson.

"Fertilizer Tests on Oats at Bluebonnet Farm, 1953," Agr. Exp. Sta., Texas A&M College, College Station, Texas, Prog. Rpt. 1623, Oct. 16, 1953, M. J. Norris, O. J. Tippit, and H. O. Hill.

Soils

"The Influence of Soil Aggregate Stabilizers on Stand, Composition, and Yield of Crops on Calcareous Soils of Southern Arizona," Agr. Exp. Sta., Univ. of Ariz., Tucson, Ariz., Tech. Bul. No. 129, July 1953, W. H. Fuller, N. C. Gomness, and L. V. Sherwood.

"Soil Drifting, Its Causes and Control," Dept. of Agr., Ottawa, Ontario, Canada, Pub. No. 896, Oct. 1953, K. W. Hill.

"Land Judging in Kansas," Ext. Serv., Kansas State College, Manhattan, Kansas, Cir. 236,

June 1953, R. C. Lind and H. B. Harper.

"You, too, can do it! Soil Testing and Plant Growth," Agr. Ext. Serv., Miss. State College, State College, Miss., Pub. 254, March 1953, I. E. Miles.

"Soil Survey, Benton County, Tennessee," USDA, S. C. S., Wash., D. C., Series 1941, No. 6, Aug. 1953, L. E. Odom, R. H. Deere, M. H. Gallatin, and W. E. Cartwright.

"Conservation and Utilization of Soil Moisture," Agr. Exp. Sta., Texas A&M College, College Station, Texas, Bul. 767, Aug. 1953, C. E. Fisher and E. Burnett.

"Soil Survey, Whatcom County, Washington," USDA, S. C. S., Wash., D. C., Series 1941, No. 7, Aug. 1953, E. N. Poulson and R. D. Flannery.

"Farming Muck and Peat in Wisconsin," Agr. Ext. Serv., Univ. of Wis., Madison, Wis., Cir. 456, Aug. 1953, A. R. Albert and O. R. Zeasman.

Crops

"Reseeding Desert Grassland Ranges in Southern Arizona," Agr. Exp. Sta., Univ. of Ariz., Tucson, Ariz., Bul. 249, July 1953, D. Anderson, L. P. Hamilton, H. G. Reynolds, and R. R. Humphrey.

"Pasture Experiments in North Arkansas 1946-1952," Agr. Exp. Sta., Univ. of Ark., Fayetteville, Ark., Bul. 537, June 1953, P. C. Sandal, R. D. Staten, and A. M. Davis.

"Report of the Minister of Agriculture for Canada for the Year Ended March 31, 1953," Minister of Agriculture, Ottawa, Ontario, Canada, Sept. 1953.

"Red Clover for Hay, Silage, Pasture, and Seed," Dept. of Agr., Experimental Farms Service, Ottawa, Ontario, Canada, Pub. 894, Sept. 1953, F. S. Nowosad, R. M. MacVicar, H. A. McLennan, A. J. MacLean, and W. E. Cordukes.

"Colorado Lawns, Planting and Maintenance," Agr. Exp. Sta., Colo. A&M College, Fort Collins, Colo., Bul. 392-A, March 1953, G. Beach and C. M. Drage.

"Growing Lupine on Coastal Bermuda Sod," Agr. Exp. Sta., Univ. of Ga., Tifton, Ga., Cir. 23, July 1953, G. W. Burton, J. L. Shepherd, and E. H. DeVane.

"Sour Grass in Hawaii," Agr. Ext. Serv., Univ. of Hawaii, Honolulu, Hawaii, Ext. Cir. 336, Aug. 1953, E. Y. Hosaka.

"Perry Soybeans for Indiana," Agr. Exp. Sta., Purdue Univ., Lafayette, Ind., Sta. Cir. 398, 1953, A. H. Probst.

"Suggestions for Improving Soft Red Winter Wheat in the Pocket Area," Agr. Ext. Serv., Purdue Univ., Lafayette, Ind., Ext. Lflt. 365, Oct. 1953, H. R. Lathrope and A. J. Ohlrogge.

"Alfalfa in Kansas," Agr. Ext. Serv., Kans. State College, Manhattan, Kans., Cir. 237, June 1953, L. E. Willoughby and E. A. Cleavinger.

"1952 Annual Report of the Director of Agricultural Extension, College of Agriculture and Home Economics, University of Kentucky," Agr. Ext. Serv., Univ. of Ky., Lexington, Ky., June 1953.

"Louisiana S1 White Clover," Agr. Exp. Sta., La. State Univ., Baton Rouge, La., Bul. No. 479, June 1953, C. R. Owen.

"Coastal Bermuda," Agr. Ext. Serv., La. State Univ., Baton Rouge, La., Pub. 1139, March 1953, R. A. Wasson and W. E. Monroe.

"Considerations in Peach Culture in Maryland," Agr. Ext. Serv., Univ. of Md., College Park, Md., Ext. Mimeo. No. 139, Jan. 1953, A. F. Vierheller.

"Annual Report for the Fiscal Year Ending June 30, 1952," Agr. Exp. Sta., Univ. of Mass., Amherst, Mass., Bul. No. 467, March 1953.

"The Home Lawn," Agr. Ext. Serv., Univ. of Minn., St. Paul, Minn., Ext. Fldr. 165, Rev. June 1953, L. C. Snyder, A. A. Granovsky, R. C. Rose, and M. F. Kern Kamp.

"Working Together, Annual Report 1952," Agr. Ext. Serv., Miss. State College, State College, Miss., Pub. 269, June 1953.

"Care of Landscape Plants," Agr. Ext. Serv., Miss. State College, State College, Miss., Pub. 261, June 1953, H. J. Smith.

"Crimson Clover," Agr. Ext. Serv., Miss. State College, State College, Miss., Pub. 265, June 1953, W. R. Thompson.

"Dallis Grass on Mississippi Farms," Agr. Ext. Serv., Miss. State College, State College, Miss., Pub. 266, June 1953, W. R. Thompson.

"Southern Peas for Market," Agr. Ext. Serv., Miss. State College, State College, Miss., Pub. 272, June 1953, K. H. Buckley.

"Growing Asparagus," Agr. Ext. Serv., Univ. of Mo., Columbia, Mo., Cir. 630, Jan. 1953, V. N. Lambeth and C. R. Cunningham.

"Nebraska Spring Small Grain Variety Tests, 1953," Agr. Exp. Sta., Univ. of Nebr., Lincoln, Nebr., Outstate Testing Cir. 31, Sept. 1953, A. F. Dreier and P. L. Ehlers.

"Forage Grasses for Hay and Pasture IV. Tall Fescue, Orchard Grass, Tall Wheatgrass, and Other Perennial Grasses," Agr. Exp. Sta., Univ. of Nev., Reno, Nev., Mimeo. Cir. 4, April 1953, J. H. Robertson and E. H. Jensen.

"Responses of Varieties of Bromegrass (Bromus inermis Leyss) to Nitrogen Fertilization and Cutting Treatments," Agr. Exp. Sta., Cornell Univ., Ithaca, N. Y., Memoir 322, Aug. 1953, H. R. Fortmann.

"Redgold Sweet Potato, A New High-Yielding—Wilt-Tolerant Variety," Agr. Exp. Sta., Okla. A&M College, Stillwater, Okla., Bul. No. B-411, Oct. 1953, H. B. Cordner, F. B. Struble, R. Reder, and L. Morrison.

"Performance of Weeping Lovegrass Under Different Management Practices," Agr. Exp. Sta., Okla. A&M College, Stillwater, Okla., Tech. Bul. No. T-48, Oct. 1953, C. E. Denman, W. C. Elder, and V. G. Heller.

"The Canby Red Raspberry," Agr. Exp. Sta., Oreg. State College, Corvallis, Oreg., Cir. of

Inf. 533, July 1953, G. F. Waldo.

"Progress Report of Research In Crops and Soils," Agr. Exp. Sta., S. Dak. State College, Brookings, S. Dak., Cir. 98, Feb. 1953, W. W. Worzella, L. F. Puhr, J. E. Grafius, C. J. Franzke, D. B. Shank, V. A. Dirks, J. G. Ross, M. W. Adams, and A. N. Hume.

"Grasses and Legumes, Production and Management for South Dakota," Agr. Exp. Sta., S. Dak. State College, Brookings, S. Dak., Bul. 427, May 1953, W. W. Worzella, L. O. Fine, J. G. Ross, M. W. Adams, L. F. Puhr, P. L. Carson, and B. L. Brage.

"Influence of Row Widths and Seeding Rates on Yields and Survival of Tall Fescue Stands," Agr. Exp. Sta., Texas A&M College, College Station, Tex., Prog. Rpt. 1601, Aug. 10, 1953, E. C. Holt.

"Greenwrap Tomato Variety and Advance Breeding Line Tests in the Lower Rio Grande Valley, Spring 1953," Agr. Exp. Sta., Tex. A&M College, College Station, Tex., Prog. Rpt. 1604, Aug. 27, 1953, P. W. Leeper and W. R. Cowley.

"Cantaloupe Variety Trial at College Station, 1953," Agr. Exp. Sta., Tex. A&M College, College Station, Tex., Prog. Rpt. 1610, Sept. 11, 1953, H. C. Mohr.

"Rio-Gold, A New Disease-Resistant Cantaloupe," Agr. Exp. Sta., Tex. A&M College, College Station, Tex., Prog. Rpt. 1613, Sept. 15, 1953, G. H. Godfrey.

"Effects of Abnormalities on Yields of Tomatoes in East Texas, 1953," Agr. Exp. Sta., Tex. A&M College, College Station, Tex., Prog. Rpt. 1614, Sept. 15, 1953, P. A. Young.

"Pickling Cucumber Variety Trial at College Station, 1953," Agr. Exp. Sta., Tex. A&M College, College Station, Tex., Prog. Rpt. 1615, Sept. 17, 1953, H. C. Mohr.

"Cotton Variety Tests in the Lower Rio Grande Valley, 1953," Agr. Exp. Sta., Tex. A&M College, College Station, Tex., Prog. Rpt. 1618, Oct. 5, 1953, J. L. Hubbard, C. S. Miller, and W. R. Cowley.

"Maturity of Several Grape Varieties in South Texas," Agr. Exp. Sta., Tex. A&M College, College Station, Tex., Prog. Rpt. 1619, Oct. 13, 1953, N. P. Maxwell.

"Salt Tolerance of Five Grasses," Agr. Exp. Sta., Tex. A&M College, College Station, Tex., Prog. Rpt. 1620, Oct. 15, 1953, H. W. Gausman.

"Variety and Strain Trials with Grain Sorghum, Broomcorn, Safflower and Popcorn in the Lower Rio Grande Valley, 1953," Agr. Exp. Sta., Tex. A&M College, College Station, Tex., Prog. Rpt. 1622, Oct. 16, 1953, C. S. Miller.

"Ginseng Culture," USDA, Wash., D. C., Farmers' Bul. No. 1184, Rev. June 1953, Div. of Tobacco, Medicinal, and Special Crops, Bur. of Plant Industry, Soils, and Agr. Engineering, Agr. Research Admin.

"Legume Inoculation: What It Is; What It Does," USDA, Wash., D. C., Farmers' Bul. No. 2003, Rev. July 1953, L. W. Erdman.

Economics

"Twenty-one Years of Citrus Costs and Returns in Orange County Florida, 1931-52," Agr. Ext. Serv., Univ. of Fla., Gainesville, Fla., AE Series No. 54-1, Oct. 1953, Z. Savage.

"Decision-Making Principles in Farm Management," Agr. Exp. Sta., Univ. of Ky., Lexington, Ky., Bul. 593, Jan. 1953, G. L. Johnson and C. B. Haver.

"Agriculture and the People of Our State, Our Nation and the World," Agr. Exp. Sta., Univ. of Mo., Columbia, Mo., Bul. 596, May 1953, M. F. Miller.

"Handbook of Facts About North Dakota Agriculture," Agr. Exp. Sta., N. Dak. Agr. College, Fargo, N. Dak., Bul. 382, Rev. Nov. 1952, B. H. Kristjanson and C. J. Heltemes.

"Commercial Apple Production and Marketing in Oconee County, South Carolina," Agr. Exp. Sta., Clemson Agr. College, Clemson, S. C., Cir. 89, Jan. 1953, B. J. Todd and C. D. Evans.

"Texas Farm Commodity Prices, 1947-52," Agr. Exp. Sta., Tex. A&M College, College Station, Tex., Bul. 764, June 1953, J. G. McNeely and V. C. Childs.

"Part-Time Farming in Washington," Agr. Ext. Serv., State College of Wash., Pullman, Wash., Ext. Cir. 236, Oct. 1953, A. J. Cagle.

"Wisconsin's Crop Calendar, Planting, Harvesting, Marketing," State Dept. of Agr., Madison, Wis., Bul. No. 319, May-June 1953, R. L. Packard.

"The Balance Sheet of Agriculture 1953, USDA, Bur. of Agr. Econ., Wash., D. C., Agr. Inf. Bul. No. 115, Sept. 1953, N. J. Wall, F. L. Garlock, L. A. Jones, R. W. Bierman, and W. H. Scofield.

"Foreign Agricultural Situation, Maps and Charts," USDA, Foreign Agr. Serv., Wash., D. C., Oct. 1953.

"Vegetables for Commercial Processing, Acreage, Production, Value," USDA, Bur. of Agr. Econ., Wash., D. C., Stat. Bul. No. 132, June 1953, I. Holmes, T. R. Hall, and O. M. Frost.

"Oh, yes," said Mrs. Gadgett, proudly, "we can trace our ancestors back to—to—well I don't know exactly who, but we've been descending for centuries."

An astronomer points out that the planet Venus cannot support life. We might add that it is also becoming a bit difficult on this planet.

Continuous Plant Cover . . .

(*From page* 20)

and left until June of the next year. The other series of plots was left fallow. Averaging these gains on a single-year basis, then 40.1 pounds of nitrogen were added to the nitrogen in the soil each successive year where the organic matter was spread on the surface of the ground.

While the clover treatment of 2.5 tons per acre annually raised the residual nitrogen in the soil above that in the untreated soil by 612 pounds during the 15-year period, the untreated soil was losing 115 pounds. Thus, 18.8 per cent (or almost one fifth) of this addition would have been needed to maintain the soil at its original nitrogen level. This would have required a half ton of clover per acre annually.

Plant Cover and Soil Aggregation

Aggregates are the structural elements of soil. Their presence and maintenance are essential to good soil tilth and a high state of productivity. Aggregate formation in soils depends upon adequate supplies of biologically active organic matter (24). The humate fraction of the organic colloids produced in the course of decomposition of organic matter by soil microorganisms appears to be the major factor contributing to formation of soil aggregates. These organic colloids, or binding agents, are distributed uniformly throughout the soil aggregates and are adsorbed to colloidal clay particles. They effectively produce stable aggregates, perhaps by electrochemical union with organic colloids. Apparently they are bound through the carbon linkage "bridge" between reactive groups on the polymer. This reaction is believed to take place mainly by polar adsorption, resulting from the decomposition of fresh organic matter.

Joined to the soil particles, the humate fraction or hydrophilic colloids serve as bridges between the particles, keeping them from separating yet at the same time holding them apart so they won't pack down tight.

Since certain other groups of soil microorganisms break down these organic colloids as they are formed, it is necessary to maintain a continuous supply of fresh organic matter in the soil if a high state of aggregation is to be maintained. This can only be accomplished by using sod or mulches to which fresh materials are added frequently to produce continuous plant cover (3, 11, 24, 27).

Plant Cover and Infiltration

Falling raindrops have great capacity to erode, damage, and destroy soils. The sharp impact as they strike the bare earth during violent rainstorms shatters the clods and soil crumbs and breaks down soil structure. The beating, churning action of these drops compacts the fine soil particles into an impervious layer of surface mud, to form "puddle erosion" (25). This compact surface layer becomes denser and more impervious as it strains colloids and other particles from the turbid rainwater that filters from the surface into the soil. This layer is the most important factor affecting the intake of water by the soil. It decreases infiltration (Fig. 5), increases runoff and soil loss, and paves the way for gully formation. Puddle erosion can be prevented by keeping the falling raindrops from striking bare soil. This can be accomplished by using suitable plant cover.

Studies conducted in Missouri suggest that plant cover in the form of crops is an important factor in maintaining favorable moisture conditions in the soil. The beneficial effects of sods turned under for corn crops have usually been ascribed to nitrogen, when possibly the important factor has been accumulated moisture in the subsoil.

Grass crops absorbed 87.4 per cent of the rainfall; a 3-year rotation with one year of sod absorbed 85.5 per cent, while continuous corn absorbed only 69.6 per cent, according to trials extending over 14 years (16). This amounted to an increased rainfall of 7.2 inches for grass and 6.4 inches for rotation compared with continuous corn. The difference in crop yield was more significant than these figures indicate, since two thirds of the annual rainfall occurred during six months of the growing season—or the period when differences in rainfall mean increased yields.

Much of the extra water absorbed moves beyond the zone of consumption by the shallow grass roots and is stored there. Thus the deeper soil layer under sod (such as the 24-36″ layer) carries more water than the same layer under tilled soil. Moisture in two similar soils, not far from those in the erosion study cited above, are interesting from this standpoint—especially for the years 1934 and 1936, which were seasons of deficient rainfall. Table V gives the moisture content as the percentage of moisture in the successive one-foot layers to a depth of 3 feet.

The 24- to 36-inch layer was much drier under the cultivated soil. Considerable time always elapsed after rain before it regained moisture, and its total water content never equaled that in the 24- to 36-inch depth under sod. Though the 0-12″ layer under sod had a lower moisture content than that under cultivation during one month (March 1936), in all samplings the moisture supply of the 12- to 24-inch and 24- to 36-inch layers was greater under sod than under the cultivated surface, with the most pronounced differences in the 24- to 36-inch depth, varying from 5.3 to 9.5 per cent. These differences mean that on the average the 24- to 36-inch layer under sod is storing the equivalent of a 1.2-inch rain, which it may supply to the sod crop, or to the deeper roots of the following crop in the drier summer season.

Plant Cover and Fertilizer

The addition of fertilizer decreases erosion losses because it increases the

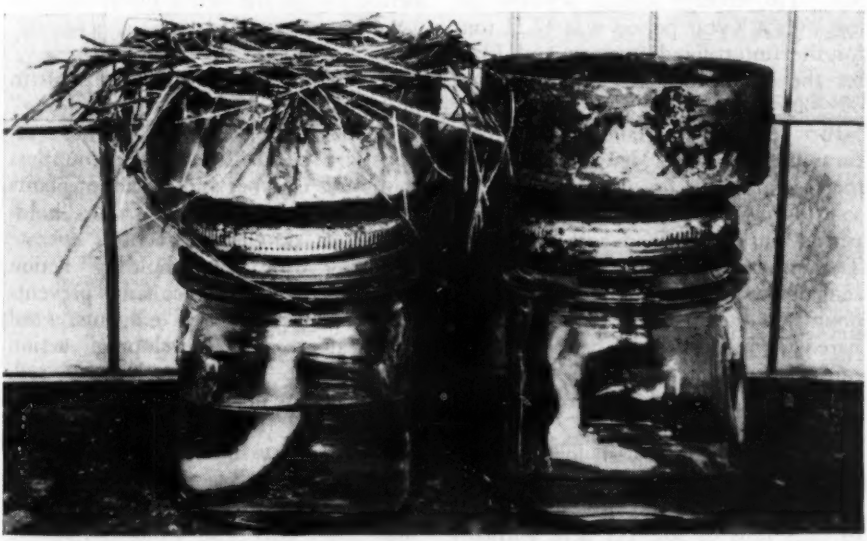

Fig. 5. Plant cover preserves the open porous structure at the surface of the ground which favors rapid infiltration. Equal amounts of soil were placed in the cups on top of the jars. Mulch cover was placed on the soil in the cup to the left; the other was left bare. Rain was then played on the soil in the two cups for about seven minutes. The greater amount of water in the jar with the mulch cover shows how it increased water intake.

TABLE V.—MOISTURE CONTENT AT SUCCESSIVE DEPTHS UNDER SOD AND UNDER CULTIVATED SOIL (2)

Date	0–12″		12–24″		24–36″	
	Sod	Cultivated	Sod	Cultivated	Sod	Cultivated
	Per cent		*Per cent*		*Per cent*	
April 1934	27.18	25.23	29.90	24.61	26.11	16.58
November 1934	33.80	31.70	31.90	30.80	32.60	24.80
March 1936	26.30	27.80	28.20	28.90	28.30	23.00
November 1936	27.00	26.80	28.50	27.30	27.80	19.80
April 1937	32.90	28.30	30.00	28.60	30.70	23.40

amount of plant cover. This is accomplished by stimulating early growth, thus hastening the date when the cover becomes effective, and by increasing the amount and density of cover. High yields and erosion control go hand in hand. Higher fertility means more vigorous crop growth. More vigorous plants provide better cover and produce higher yields.

Two plots in Wisconsin were planted to a 3-year rotation of corn, oats, and hay. The oats in one rotation were fertilized and those in the other were not. The average annual per-acre soil loss over a 5-year period was 47.21 tons for the unfertilized rotation and 13.13 for the fertilized one (13). The use of 200 pounds per acre annually of 5-10-5 fertilizer on land planted continuously to corn in New York reduced the loss of water by one third and the soil loss by two fifths over a 9-year period on unfertilized cornland (14). The unfertilized corn plot lost 9.5 per cent of the rainfall as runoff and 5,934 pounds of soil per acre annually compared with a loss of 6.4 per cent of the rainfall as runoff and 3,552 pounds of soil per acre for the plot receiving the fertilizer.

Unfertilized Shelby silt loam in Missouri planted to a 3-year rotation of corn, wheat, and hay lost an average of 8.81 tons of soil per acre annually during a 7-year period, compared with a loss of 3.69 tons for similar soil fertilized and planted to the same rotation (29).

A comparison of soil loss under wheat and oats (both with and without fertilizer) illustrates the effectiveness of fertilizer in reducing losses by erosion. Soil loss from land in wheat was reduced by one half, while the loss from oats was reduced more than one half as a result of the increased cover obtained by the use of 200 pounds of fertilizer per acre (20) (Fig. 6). At the same time, the wheat yield was increased 91 per cent and the oat yield 77 per cent on the average over a 7-year period by the use of fertilizer.

Summary

Nature employs two distinct steps to build soil. These are the "holding" and "developing" actions. These actions are performed by the countless thousands of types and species of plants that inhabit the earth. These "holding" and "developing" actions operate simultaneously. The "holding" action keeps the soil in place and prevents its removal by the erosive agents, wind and water. The "developing" action changes the parent rock into soil. These actions operate in such a way as to build soil from the top downward.

The primary function of plant cover in the "holding" action is to protect the soil from erosion by absorbing the destructive energy of wind and falling raindrops. Plant cover reduces the velocity of the wind to such an extent that it no longer possesses energy

enough to start the saltation movement (the major factor in wind erosion). It also traps soil particles from adjacent areas that may be subject to wind erosion.

Raindrop impact is the major factor in the water erosion process. Plant cover serves as a springy cushion to intercept falling raindrops and prevent them from striking the ground surface before being relieved of their kinetic energy. Raindrops are thus prevented from tearing the soil particles loose and carrying them away in the runoff water. The raindrops are also prevented from puddling and sealing the soil surface. This enables the soil to maintain a high infiltration rate and reduces runoff.

By maintaining a continuous supply of easily decomposable organic matter on the surface of the ground, plant cover produces and maintains good soil tilth. This is achieved by supplying, in the form of leachings, the humate fractions of organic colloids which appear to be responsible for the production of aggregates or crumbs that are essential to good structure. Plant cover also keeps the loss of plant nutrients and soil organic matter by erosion to an absolute minimum. By keeping erosion losses to negligible quantities, it is possible to hold the soil in place and build it up at the same time.

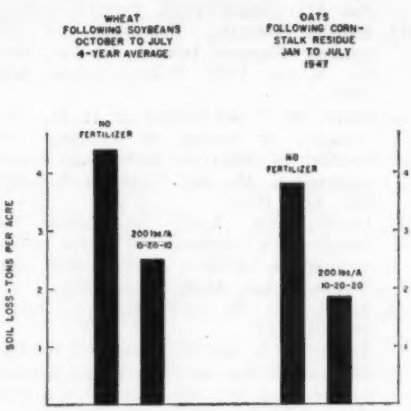

Fig. 6. Effect of Fertilizer on erosion of land planted to small grain.

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Nebuchadnezzar Ate Grass . . .

(*From page* 10)

content is high enough to feed the bacteria that bring about their decay and leave a lot over for the crop that follows.

But we have passed the stage where we can place all our dependence on legumes to supply nitrogen. In fact unless we have a feed use for the legumes, we often cannot afford to grow it. Intensive cropping requires a lot more nitrogen than can be obtained by the legume route. And this applies even to a livestock farm where manure is saved and returned to the field. It must be kept in mind that use of purchased feeds is an excellent system to build up the fertility of one farm at the expense of another. It does not solve the fertility problem as a whole.

A highly important need for today is that we develop cropping systems that prevent rain from ever striking the soil. This is a difficult assignment. The interest that has been aroused in Indiana and Illinois in widening the distance between corn rows and growing soybeans and clover in between is evidence that this need is recognized. So far as organic matter is concerned, corn after corn with the stalks plowed under is a good system. Corn after corn with the stover removed, even with rye as a winter cover, leaves much to be desired.

Judging by Nebuchadnezzar's experience, all of us need to be turned out to grass from time to time. For my part, I prefer to feed the grass first to the cow. If there is no cow around, there are plenty of other means by which soils can be kept in a high state of fertility and in good physical condition. However, grass usually enters the picture in some form, if nothing more than as a winter or in-between-crop cover of ryegrass, rye, or Sudan grass for working into the soil.

General Rules Concerning Plant Nutrients

(*From page* 24)

or similar high rates sometimes gave large yield increases.

A very common reason for no response is the arbitrary one of strict requirements for significance. Lack of statistical significance does not assure that there is no response, but may mean that the response is too small for measurement by the rules or that the experiment was not sufficiently precise. It is seldom that our common experimental procedures will detect responses smaller than 10-20 per cent. Experiments to detect much smaller amounts are cumbersome and expensive. Such responses, however, should not be overlooked and in this range we should certainly never trust our eyes.

There are several other factors such as unfavorable temperature, diseases, insects, and drought that could result in no-response fertilizer experiments. One should never hesitate to try a second time. This is better appreciated when we understand Rule 3.

Rule 3—For most nutrient elements, no soil is inexhaustible. This is not implied to mean that plant nutrition can be maintained according to the bank-account theory, nor that slow and uniform but controlled erosion will not provide sufficient new soil to grow crops indefinitely. Soils that have become depleted in one or more of the nutrient elements but which at one time provided sufficient of that nutrient are continually being found. The nitrogen status of the rich, black rendzina soils of Texas is an excellent example. More than 100 years ago those prairie soils were plowed and planted to cotton. After 100 years of continuous cotton they, once thought inexhaustible, now respond to nitrogen. Furthermore, on certain of those soils there is not sufficient of the original high content of soil organic matter to maintain proper soil structure.

California fruit growers in Santa Clara Valley, northern Sacramento Valley, and lower San Joaquin Valley are now finding that potash is needed on some of the soils of those regions. A need for phosphorus has recently been recognized also, notably on some citrus soils in southern California. A survey in Utah revealed that potassium was being permanently removed from soils there more rapidly than any other nutrient element. As yet no potash responses of which the writer is aware have been reported in that State.

"Lime enricheth the father and impoverisheth the son." This was a common objection to the use of lime in the recent past. It is now recognized that one cause of the dilemma was that the increased growth caused by the lime hastened the depletion of other nutrient elements.

Minor-element deficiencies are being newly found in a large number of agricultural areas. These have not always existed but the soils are becoming exhausted. This is true especially when the soils are cropped "intensively." In many cases the nutrients do not become exhausted but do become unavailable to plants. Such can occur, for example, when good soil structure is lost, when excesses of some types of fertilizers or amendments are applied to the soil, or when the soil becomes excessively acid or alkaline.

Rule 4—Nitrogen fertilizer is nearly always needed regardless of the soil or of the crop. There are some, but few, soils on which this is not true. There are vegetative and reproductive complications. Nitrogen is the one element most likely to be deficient on any soil. The chemical nature of nitrogen is largely responsible. Nitrogen is stored in soils either as a constituent of the soil organic matter or as the nitrate ion and occasionally as the adsorbed am-

monium cation. Soil organic matter is a nonstable entity. Continued cultivation leads to its destruction so that the nitrogen supply becomes low and the soil structure becomes unfavorable for plant growth. Nitrate nitrogen, which is ordinarily formed when soil organic matter decomposes, is rapidly leached from the soil. Large quantities are found at depths of 25 feet and deeper in citrus soils in California that have been heavily fertilized. Adsorbed ammonia has been shown recently to become fixed and very slowly available in some soils.

In many sections of the United States it has been felt for many years that most every crop needs a complete fertilizer and fairly large amounts of it. This has not generally been believed true for the fertile lands of the West. Western soils do, however, need fertilizers. Large responses were obtained when phosphorus was first used on sugar beets, alfalfa, small grains, and other crops on many soils in the West. Even so, the yield of sugar beets soon began to drop until recently phenomenal yield increases have been obtained for commercial nitrogen additions.

Nitrogen, except for some foliar applied zinc and some phosphorus and potash, has been the only fertilizer element applied in quantity to fruit trees in the West. Certain fruits do require precise nitrogen control because of time of maturity and fruit quality requirements. Most truck crops are sidedressed with nitrogen once or more during their crop history. Nitrogen fertilizer often increases both yield and protein content of small grains. There is some doubt about certain legumes being able to fix sufficient nitrogen for their maximum growth. So widespread is the need and use for nitrogen that a recent survey revealed that from 50 to 70 per cent of the major farming sections of California are deficient in available nitrogen. And California is one of the more fertile western states. California uses about 100,000 tons of commercial nitrogen per year, or about 10 per cent of the total consumed in the United States. The same survey revealed that about 50 per cent of California soils were in need of phosphorus —depending on the crop to be grown. Extremely large amounts of phosphorus and potassium fertilizers are needed and used throughout the country, but their use cannot be generalized as easily as that of nitrogen.

An important reason for the need of large quantities of fertilizers is the relatively low efficiency of utilization of some of them.

Rule 5—The efficiency of utilization of fertilizers is usually low but can be improved by better management practices. Citrus trees in California commonly receive three or more pounds of nitrogen per tree. The crop ordinarily removes about one-half pound of nitrogen per tree. Other nitrogen in the tree returns to the soil when leaves, blossoms, and immature fruit are shed. The efficiency of nitrogen use by this crop at the 4-pound rate is ordinarily between 10 and 15 per cent. Chapman has suggested a list of practices including more frequent but smaller applications preferably in the irrigation water, sprinkler instead of furrow irrigation, more widespread use of nontillage, and slight acidification of the surface soil to prevent volatilization losses that could increase the efficiency of nitrogen use by citrus.

Application of fertilizers by topdressing to alfalfa for a three-year period in New Brunswick, New Jersey, resulted in an average of 17 per cent recovery in the tops for nitrogen, 18 per cent for phosphorus, and 68 per cent for potassium. One per cent of the molybdenum in a 5-pound per acre application of sodium molybdate was recovered in one year, as measured by analysis of tops and roots. Only 0.2 per cent of the cobalt in a 5-pound per acre application of cobalt nitrate was present in the foliage of one year of crop thereafter. Even so, the additional content of each of these two elements was over 700 per cent more than the controls where no additions were made.

Efficiency in potash absorption was improved by applying the fertilizer early in the spring (82%) or in early summer (78%), as compared to fall application (52%). Small applications were more efficiently utilized than large applications, although the large applications gave the highest yields. Some investigations have obtained opposite results, especially in the range of applications that were too small to produce a response. It is generally believed that in topdressing alfalfa with potash frequent small applications are much better than single large applications. On the potassium-deficient alfalfa soils of Butte County in California, however, small applications of potash were not effective, but application of 600 to 800 pounds per acre produced large increases in yield.

In nitrogen studies with oats made by Bartholomew, et al. using heavy nitrogen as a tracer, the per cent of nitrogen in the plants coming from fertilizer was 10-15 per cent when 20 pounds per acre were applied and 15-20 per cent when 40 pounds were applied. The per cent recovery of the fertilizer nitrogen was higher for the smaller rate and decreased for both rates when applied after the crop was partly grown, varying from 10 to 30 per cent. Similar results have been obtained by many workers using radioactive phosphorus as a tracer in phosphorus fertilizers. Smith and Simpson give a range of from 5 to 40 per cent for the uptake of phosphorus from phosphate fertilizers. This is quite a range and has many practical considerations. This entire subject involves all the factors influencing the availability and fixation of plant nutrients.

There are other points that could be made in this discussion. For example, the various textbooks on soil fertility usually list crops most likely to respond to certain nutrients. How and when to apply fertilizers are pertinent problems. Pedologists and other soil scientists are likely to demand a very thorough knowledge of the soil as the basis for solving fertility problems, and their stand would be justifiable. New biochemical discoveries in plant behavior currently are making more publicity than findings in soil fertility, but they undoubtedly will be stepping stones to new information on soil fertility and plant nutrition. The writer never travels about the country without being impressed by the tremendous rural progress during the past decade or so, much of which has come about by more and better use of commercial fertilizers.

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Poor Practices Steal Much Farm Income

SEVEN undesirable farming characteristics steal much farm income. They are low volume of production, bad weather, high costs, low prices, low yields, inefficient livestock, and poor cropping systems.

There's not much you can do about the weather or the general price level. But J. B. Claar, Farm Management Specialist at the Illinois College of Agriculture, says you can combat the others if you will study your business and correct its weaknesses.

Farm Bureau Farm Management Service records show that the value of total production on the average 160-acre grain farm last year was less than $11,000. Figuring all costs, only $110 was left to pay for management ability. If your farm uses less than 24 months of labor, this low-volume thief may be stealing from you.

You can improve low yields and low volume of business with a good cropping system and a fertility program, Claar says, and give yourself some protection against bad weather. Your cropping system should include all the high-profit crops you can grow and still keep your farm in good condition.

A careful study of farm records to find out what is wrong will help lick high costs and inefficient livestock.

White Birch Helps Restore . . .

(*From page* 12)

If so, the foregoing discussion would need modification, for the soil would have been supplied vital nutrients released from the organic debris following decomposition. As a result a condition favorable for establishment and growth of birch, and subsequently pine, would have followed. However, no peculiarities such as charred wood or darkened organic leachates were found in the soil.

A more plausible explanation is that birch, by its strong nutrient cycle, supplies organic matter which enriches the soil directly under the crown. This continual return of nutrients to the soil through deposition of leaf litter on the surface, followed by decay and leaching, is not unusual. It is an important factor influencing soil fertility. Plow zone calcium concentrations, for instance, are significantly greater under red cedar crowns than under neighboring red pines on abandoned field soils in Connecticut. And when maple and pine logging slash or pine-hemlock humus from natural woodlands is applied to potash-deficient soils in New York, substantial increases in pine and spruce vigor follow. These applications also result in higher potassium concentrations in needles. Thus, one might say the nutrients were restored to the surface soil by the "pumping action" of the birch.

Summary

White birch exerts an appreciable influence in increasing exchangeable potassium in plow zones of sandy soil in Adirondack old fields. As a result, young white pines grow well under birch crowns, while those in adjacent openings do not.

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The Share of Crop Nutrients . . .

(*From page* 26)

the Eastern and Western parts of the Cotton Belt. In the East the crop is as a rule grown on light soils which are practically devoid of nitrogen. Here nearly all of its nitrogen must come from commercial sources. On the other hand, a substantial part of the total cotton grown in the United States comes from the semi-arid sections of Texas where the soil still contains much organic material and where little commercial nitrogen is, therefore, used.

The weighted averge of all the individual ratio figures listed for nitrogen amounts to 17 per cent. That is to say, despite the heavy expansion which during recent years has occurred in the use of commercial fertilizer, less than one fifth of the total nitrogen contained in harvested crops or pastured plants

comes from commercial sources. The remaining quantities are obtained, of course, from manure, from soil nitrogen, and, above all, from legumes. Calculations prepared by the author have shown that the figures applying to these items are, on an annual basis, approximately 1.4 million tons each for manure as well as for soil nitrogen and 3.3 million tons for the legumes.

The latter figure seems surprisingly high. Some of the leguminous crops grown are, however, rather rich in nitrogen. To illustrate, the nearly 30 million tons of alfalfa hay annually harvested in the United States contain almost one million tons of this plant food. Moreover, enormous quantities of leguminous nitrogen are regularly added, of course, to the soil and thereby become available to subsequent crops through the widespread practice of turning under a crop of clover or of some related plant.

We shall next look at the figures for phosphoric oxide listed in Table II. With respect to this plant food the conditions entirely differ from those prevailing for nitrogen. In the first place, the over-all ratio figure for phosphoric oxide is 99 per cent. In other words, for the country as a whole practically as much of this plant food is applied in the form of commercial fertilizer as is contained in all of the plants either harvested or pastured off the land. Since a substantial portion of the phosphoric oxide contained in the plants is always returned to the land in the form of manure, the soils of the United States must slowly become richer, generally speaking, in their content of phosphorus. Most of the quantities thus added become to some extent unavailable, since practically all soils at once "fix" a substantial part of the phosphoric oxide applied.

TABLE II.—PER CENT OF THE TOTAL PLANT FOOD CONTAINED IN CROPS ADDED IN COMMERCIAL FERTILIZER, SEASON OF 1950/51 *

	Nitrogen	Phosphoric oxide	Potash
Corn	30	95	70
Small grains	12	187	81
Cotton	62	74	29
Vegetables, incl. potatoes, and fruits	96	173	94
Tobacco	95	1,480	100
Hay and pasture	3	73	11
Other crops	3	44	15
Total	17	99	33

* Source: All figures were calculated by the author with the help of those presented in Table I.

The individual figures listed show that this accumulation of phosphorus in the soil is most pronounced in the cases of tobacco, small grains, and vegetables and fruits, all of which crops receive two or even more times as much phosphoric oxide in the form of commercial fertilizer as they remove from the soil.

For cotton, however, we again have an intermediary ratio figure amounting to 74 per cent. The regional data prepared by the author, which because of space limitations cannot be presented in this article, show that in the Southeast phosphoric oxide is applied to cotton substantially in excess of the removal. Since almost three fourths of all the cotton grown in the United States come, however, from the Midsouth or the tier of States extending from Texas to the Pacific Coast and since in all of these regions applications of commercial phosphoric oxide are small, this crop shows for the country as a whole only a moderately high ratio figure.

The situation is similar with respect to hay and pasture. Regarding these crops a limited overapplication of the commercial phosphoric oxide seems to occur in many parts of the East as well as in the Corn Belt. On the other hand, here, too, the applications are very small in the West and on the Pacific Coast so that for the country as a whole an intermediary ratio figure of 73 is valid.

We shall finally look at the figures for potash. In the case of this plant food the situation is somewhat similar to that which exists regarding nitrogen.

That is to say, for all crops and pastures together the commercial product represents only a comparatively small share (33 per cent) of the total potash contained in harvested crops and pastured plants, which amounts to about 4.1 million tons. The larger part of the remaining 67 per cent comes, of course, from the soil; for the leguminous route does not exist in the case of potash while the statistical data available suggest that all crops harvested and all plants pastured off the land in the Continental United States annually receive from manure only about 1.3 million tons of potash. That crops and pastures should obtain a very substantial part of their potash from the soil, can be readily explained through the fact that the plow-depth of an acre of soil may contain about 30,000 pounds of potash which figure is far in excess of those applying to nitrogen and phosphoric oxide.

In so far as the potash situation of the individual crops is concerned, Table II again lists high ratio figures for tobacco and for vegetables or fruits. Evidently these plants yield so much per acre and they need, therefore, such large amounts of potash that the quantity contained in the soil in available form can supply only a very small part of these needs.

Corn and small grains, too, show in the case of potash rather high ratio figures (70 and 81 per cent respectively). It seems that the explanation for these figures must mainly be seen in the rather high potash content of many of the mixtures today used in the Midwest.

Turning next to cotton, the low ratio figure of 29 per cent listed in Table II at first glance surprises. Here, too, it is necessary, however, to bear in mind that today a very large part of all the cotton grown in the United States comes from the Western parts of the Belt where little commercial potash is used.

Finally, hay and pasture carry in our Table II a ratio figure of 11 per cent. Since manure apparently makes available to hay and pasture every year only a few hundred thousand tons of potash, while Table I shows that the total hay harvested in the United States and the total plants pastured off the land there contained together about 2.1 million tons of this plant food, hay and pasture evidently in a large measure depend on the soil for the potash they need.

One Plus or Minus

(*From page* 5)

of Agriculture. Upon receiving it from the superintendent of documents he found to his chagrin that it merely discussed the budget and home problems of the great mass of unattached females—the "government gals" of the District of Columbia. Being both unwilling and unable to strike up a partnership with one of these clever single-livers, he has kept plodding along in a rented room, not knowing or caring what comforts he has rejected.

But the real test and the best antidote involved in single residence are to reach and grow outwardly, not to mope and hide inside a barren cell.

I presume this is why no other season in our calendar of events has such a strong meaning to old and young, married and single, as the month of December and what it represents in all our past experiences. It may not always hold the soft touch of security or the sense of belonging, because not all of us can be equally fortunate in our lives and associations.

Yet what unites us at Christmas is a desire to be together. Humanity is always more or less lonely even in crowds on a gala day, unless the

spirit is stirred and invigorated by some overwhelming truth and helpful belief.

We have this sweet truth and healing belief to sustain us as kindred sojourners in the experiences of life—the worshipful attitudes that characterize Christmas and bring us nearer to a common understanding. Those good old hearty neighborhood gatherings remain, sometimes even in these hectic days of commercialized amusement, to refresh us and reunite us for that season that memories make dear and delectable.

If we of the elder generation have no secret errands to run and sly purchases to make for the sake of the boys and girls of our own at Christmastide, we can at least find other ways to reach out and be kindly and encouraging. It is quite possible, too, that we can repeat our Santa antics for the happiness of grandchildren—not one whit less appreciative or responsive than the little ones of the 1920's, now grown into sober and solid citizens with kiddies of their own.

Of course, you have to be very careful in these holiday doings not to get off by yourself again and start to overwork that vivid memory. Sometimes one wonders why memories stay so clear after many, many years. Maybe it would be a lot better for our memories to falter a little and be less irritating or provocative of tears. If you let memory haunt you with those Dickensonian visions of "Christmas past," it is quite likely that your enjoyment of "Christmas present" will suffer a setback in zest and joy. It was quite the contrary with the Scrooge story. Scrooge had so many Christmas sins to repent that he found nothing but the keenest of pleasure in surveying the plum pudding and turkey of "Christmas present."

But with you, Mister Old-time Householder, all Christmas memories that you can conjure up through the mists of yesteryears seem to be unblemished, bright, and happy ones. Everyone was well and hearty. All the old familiar faces and kindly voices were there. Dinners were long in the preparation and very appetizing in the eating thereof. Social intercourse with old friends was highlighted with toddy and song. Late hours were overlooked and future daily cares forgotten.

It was then that all that utter nonsense about terrible mothers-in-law got so badly shattered. Because it was your mother-in-law who always made such delicious mince pies and schaum torte for the Christmas festivities. And she usually served you the biggest piece of both with a wide and friendly smile that made you remember that she had taken the place of your own mother—long since gone beyond the Christmas circle.

This, therefore, is the stuff that "dangerous" dreams are made of at Christmas time—dangerous if their coming causes one to forget the duties and the pleasures of the living present. For it took all of those traditional happy holidays to fortify you for the ones to come that will not quite compare. But in the place of a bereft attitude and one of dismal looking backward, this is really the time to be proud of what has been experienced and what has been shared—scenes that time can never erase or belittle.

To have had Christmas at all is in itself a blessing, because we know of so many millions of the world's people who lack anything like it. In thus thinking of their deprived condition we are not like so many "expanders" and go-getting commercialists who believe that the real salvation of foreigners is to get wise to America's way of doing business. Christmas observance, it is true, has been invaded much by salesmanship and manifestations of that pressure and persuasion that we like to see in commerce.

Not for a moment do we mix this up with the vital feeling that pervades our lives upon nearing the happy Christmas season again. It is that serenity and hopeful poise that would be the best of things to export to hosts

without much of them. In doing that we would not fret over dollar exchange or tariff concessions, and we would probably receive some valuable "goods" in return devoid of duties and immune to shipwreck or disaster.

As we look backward along the course of time to those joyful reunions and sacred worship that marks the celebration of Christmas, we seldom remember what presents we received from whom; but instead, we recall the honesty and simplicity and all-abiding faith which our humble neighborhood evinced as Christmas cards were sent and evergreens gathered.

Once I lost a friend. Again I lost another. In due time I shall part with more. Each and all of them raise up memories of numerous Christmas pleasures for the experiencing of which I am much stronger and better to serve out my own allotted span.

One of those comrades fell ill in a distant city a few years ago. Although I was unable to visit the hospital, this comrade wrote me that my presence seemed to rest in that little room, over there in that fat old leather chair beside the iron bed, only a handclasp away.

I have always maintained that there is such strength and power in the steadfast human spirit that no sorrow or disaster can wholly ruin it. Some faddists of the modern cults proclaim that this is merely a burst of the neurotic temperament. They claim that tears and a heart bowed down are signs either of senility or of nervous disorders, possibly tracing to frustrations or maladjustments in youth. To my simple way of living and learning, that is blasted nonsense.

In only one regard do I meet their views. If one continues to shed misery and mourning all over the premises, not looking for some ways to be of aid to other unfortunate people, he ought to brace himself and come out of it. For most of us are sure that true sympathy seldom is born to mankind until one goes through the valley of the shadow part way with a friend.

Left—untreated onion; Right—treated with MH-40

Naugatuck nips storage growth in bud!

Naugatuck Chemical has good reason to believe it has dealt a death blow to destructive storage growth of crops such as onions. The reason is a unique new chemical—a water-soluble salt containing 40% maleic hydrazide and called MH-40.*

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A woman driving 70 miles an hour noticed a motorcycle cop tailing her and thought she could shake him by speeding up to 80. When she looked again she saw two cops behind her. Suddenly she spotted a gas station and pulled up to a screeching stop in front of it, leaped out, and dashed into the room marked "Ladies." When she came out the cops were still there. Without batting an eye the lady said coyly, "I'll bet you thought I wouldn't make it."

* * *

Let the woman dearest to a man say tenderly: "You were so handsome tonight, dear. I was proud of you." Then see his face light up with noble unselfish joy, because he has given pleasure to others.

* * *

He—"Did anyone ever tell you that you have beautiful eyes?"

She—"Not while looking where you are."

* * *

A hillbilly was called as a witness in a lawsuit.

"Can you write," asked the lawyer for the plaintiff.

"Nope."

"Can you read?"

"Well, I kin read figgers pretty good, but I don't do so good with writing. Now take these signs along the roads. I kin tell how furto but not whurto."

Joe and Al were celebrating one night, and the next day Joe visited his buddy in the hospital.

Al: "What happened to me last night?"

Joe: "Well, we were having a good time, and suddenly you climbed out on the window sill and said you thought you'd fly around for awhile."

Al: "Why didn't you stop me?"

Joe: "Well, to tell the truth, just about that time I thought you really could fly."

* * *

Awakened in the middle of the night, the sleepy man lifted the telephone receiver and heard a woman say:

Voice—"Hello! Are you Harry?"

Man (growling)—"No. But I'm not bald by a long sight either!"

* * *

"I have a pain in my abdomen," said the rookie to the army doctor.

"Young man," replied the medico, "officers have abdomens, sergeants have stomachs, YOU have a bellyache."

* * *

Doc: "It's a good thing you came to me when you did, my good friend."

Bill: "Why, Doc? Yuh broke?"

* * *

When telling an alleged funny story, always make it as short as possible. If you build it up and stretch it out, you give your listener time to think of a worse one to tell you.

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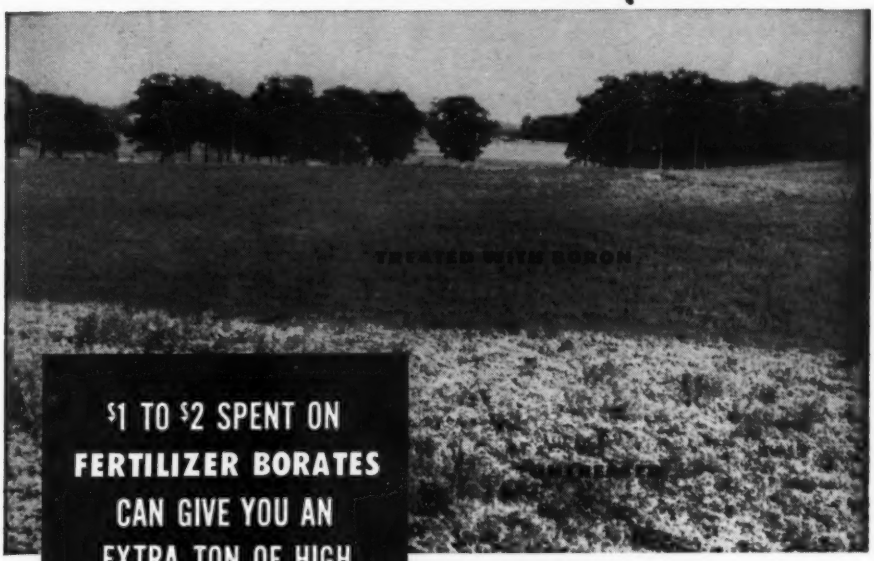

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